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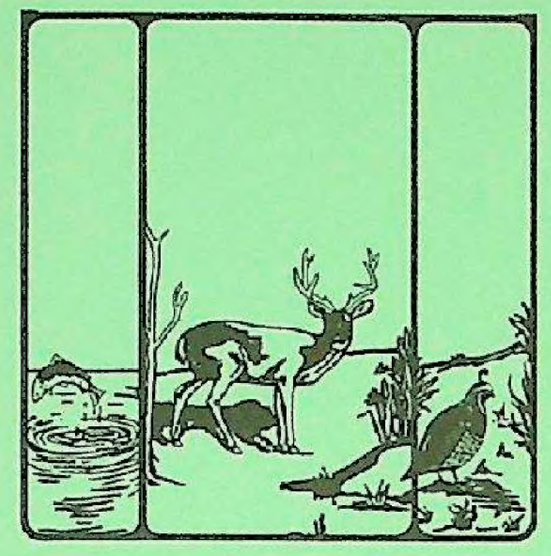

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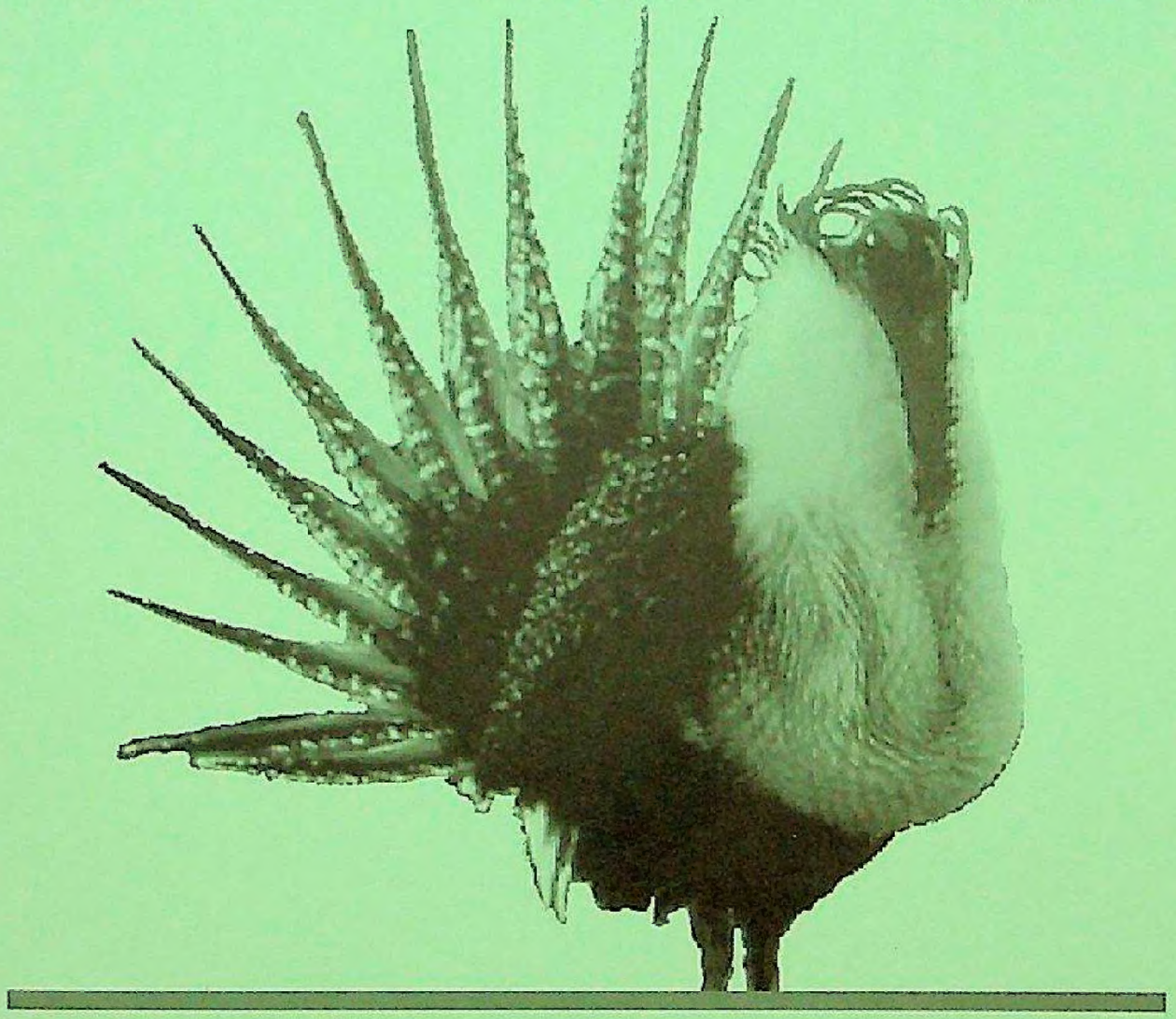
VOLUME 82 SPRING 1996 NUMBER 2



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Male Sage Grouse
Photograph by Fred Ebert,
Outdoor California Photography Award Program, 1990

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REVISED MEASUREMENTS FOR CLASSIFICATION OF AGE OF SAGE GROUSE FROM WINGS

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Measurements of primary number 4 (P4) from 294 sage grouse, *Centrocercus urophasianus*, wings from Oregon revealed that P4 was 3-5% shorter than measurements recorded for comparable sex and age groups of sage grouse from Nevada. We recommend revising the key commonly used to classify age of sage grouse by wing measurements to reflect the regional size variation found in this study.

INTRODUCTION

Plumage characteristics, especially those associated with wings, often are used to identify sex and age classes of game birds (Larson and Taber 1980). Measurements of wing and feather lengths, typically with "wing boards," facilitate sex and age classification and use of measurements does not necessitate the same level of expertise as does the use of more subtle plumage differences. Further, measurements of feathers are particularly useful with partial or damaged wings or when other characters are inconclusive. Usefulness of sex and age classification by wing measurements is dependent upon the accuracy of data from which the key was developed.

During several "wing bees" to ascertain sex and age composition of the fall sage grouse, *Centrocercus urophasianus*, harvest in Oregon, we observed that measurements based on the work of Crunden (1963) in Nevada, a commonly used key for feather measurements (Johnsgard 1980), appeared inappropriate. In many instances, we observed wings that exhibited features characteristic of adults (e.g., molting one or both outer primaries, wear on secondaries, appearance of primary coverts), but that would be classified as immatures based on the criteria of Crunden (1963). In addition, approximately 5% of the sample came from examination of entire birds. Regional or subspecific variations in feather lengths have been reported for other species of grouse (Larson and Taber 1980) and also may occur in sage grouse. Consequently, we obtained wings collected by the Oregon Department of Fish and Wildlife from hunters during the 1992 sage grouse season to test the hypothesis that wing measurements of sage grouse from Oregon differed from those reported for sage grouse in Nevada. The goal of the project was to determine if differences existed and to more accurately describe measurements so that errors in age classification could be reduced.

METHODS

Wings of hunter-shot grouse were collected from five counties in southeastern Oregon. Wings from birds shot on 15-16 September 1992 were frozen until February 1993. A total of 323 wings was collected, but sample size was 294 because some wings were not usable. Primaries (P) were numbered 1 through 10, proximal to distal (Larson and Taber 1980). Thus, P4 in this study corresponded to P7 in Eng (1955), Crunden (1963), and Dalke et al. (1963).

Sex and age were classified by several characteristics of the wings. Sex was assigned by the appearance of the primary and marginal coverts (Eng 1955). Age was based on i) the molt sequence of primaries (P9 or P10 molted, adult; P9 longer than P8, immature) (Beck et al.[1] 1975); ii) appearance (color, shape, and wear) of primaries, secondaries, and coverts (Eng 1955); and iii) presence of juvenile feathers in the plumage (secondaries, primaries, or proximal secondary coverts). We examined the entire sample twice to check for consistency of sex and age classifications.

A measurement board with an aluminum ruler set flush into the surface of the board was constructed that allowed measurement of the flattened feathers to the nearest millimeter (Eng 1955, Crunden 1963). Each flattened feather was measured three times from carpal joint to the tip of P4. Mean values were used for comparison with data from Crunden (1963).

We followed Crunden's (1963) use of the length of P4 to differentiate adult and immature birds. In our study, P4 was completely grown for all birds and all were molting one or more of P5 through P10. Although a number of birds had molted P9 and P10, we were able to differentiate yearlings from older adults for 70 females (45 and 25, respectively) and 25 males (9 and 16, respectively). Preliminary analyses revealed no significant differences in lengths of P4 between yearlings and older adults for females ($t = 0.99$, $P > 0.35$) or males ($t = 0.41$, $P > 0.50$); consequently, yearlings were classified with adults. We ascertained that P4 had completed growth by removal of the feathers from the wings after measurements were taken. A hardened tip of the calamus and absence of sheathing material or blood, which are associated with growing feathers, were used to verify completed growth.

Mean lengths of P4 for each of the four sex and age categories of Oregon birds were compared with data reported by Crunden (1963) for Nevada by the use of t-tests. Division points were determined by calculation of the difference between the mean values of adult and immature measurements, dividing that number by 2, and adding that figure to the mean for immatures (Eng 1955, Crunden 1963).

---

[1] Beck, T.D., R.B. Gill, and C.E. Braun. 1975. Sex and age determination of sage grouse from wing characteristics. Outdoor Facts, Colorado Game, Fish, and Parks Department, Leaflet No. 49.

RESULTS AND DISCUSSION

Lengths of P4 for all four sex and age categories of sage grouse from Oregon were significantly shorter (3-5%) than reported measurements of Nevada birds ($P < 0.01$) (Table 1). Mean lengths of P4 were as follows: i) adult females, 215 mm; ii) immature females, 201 mm; iii) adult males, 261 mm; and iv) immature males, 237 mm. Division points for adult and immature birds from Oregon were established at 209 mm for females and 248 mm for males, compared with 215 mm and 259 mm, respectively, for Nevada birds (Crunden 1963). Maxima and minima for lengths of P4 for all groups also were less for birds from Oregon (Table 1). Continuing to use the division points established for Nevada would result in misclassification of all but the very largest birds in this study (Fig. 1). For adult females, the misclassification rate is 26.2% (33/126), and for adult males, the rate is 48.6% (34/70). As a result, this population would have a disproportionate number of individuals classified as juveniles.

These results revealed regional variation in wing measurements of sage grouse collected during the fall and provided information for refinement of the method to classify age of these birds. We do not have comparable feather measurements from other areas, but if P4 length differs in other areas, errors may have been made in age classification. For birds from Oregon, and for smaller sage grouse elsewhere, these errors result in misclassification of adults as immatures. Consequently, the immature:adult ratio would be inflated and judgements about reproductive success,

Table 1. Wing measurements (carpal joint to tip of Primary 4) for sage grouse from Nevada and Oregon.

		Length (mm)			
Category	N	Mean	SD	Range	Location [a]
Adult male[b]	90	270	6	256-290	Nevada
	75	261	9	227-283	Oregon
Immature male[b]	127	248	6	235-262	Nevada
	45	237	12	210-259	Oregon
Adult female[b]	175	223	6	213-242	Nevada
	126	215	9	213-234	Oregon
Immature female[b]	177	206	6	189-218	Nevada
	48	201	5	188-211	Oregon

[a] Nevada values from Crunden (1963)

[b] Significant difference ($P < 0.01$) between mean wing measurements of birds from Nevada and Oregon.

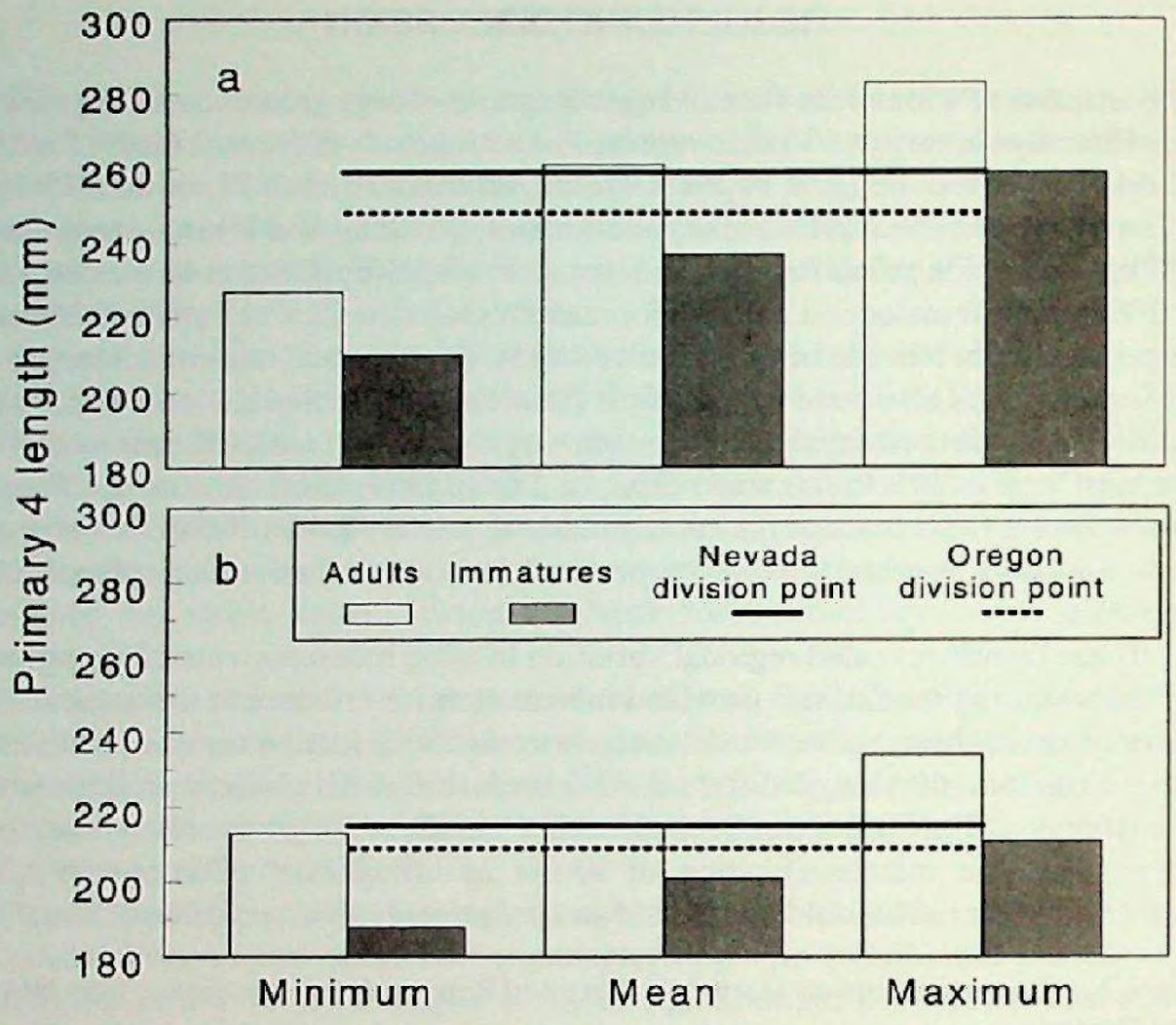

Figure 1. Minimum, mean, and maximum lengths of Primary 4 of (a) male and (b) female sage grouse collected in Oregon in 1992. Horizontal lines are Nevada and Oregon division points used to differentiate adults from immatures.

a primary population parameter, would be overly optimistic. We suggest that measurements used for classification of sex and age of sage grouse from Oregon be revised to reflect the shorter lengths of P4 to reduce error in determination of age of sage grouse from wings in this area. Further, birds from other states (California and Washington) should be examined to determine if these differences are characteristic of birds in the western part of sage grouse range.

ACKNOWLEDGMENTS

We thank personnel of the Oregon Department of Fish and Wildlife for their cooperation, D.J. Bernsten for his help with the statistics, and K.J. Ottomeier for constructing the wing board.

LITERATURE CITED

Crunden, C.W. 1963. Age and sex of sage grouse from wings. Journal of Wildlife Management 27:811-841.

Dalke, P.D., D.B. Pyrah, D.C. Stanton, J.E. Crawford, and E.F. Schlatterer. 1963. Ecology, productivity, and management of sage grouse in Idaho. Journal of Wildlife Management 27:267-272.

Eng, R.L. 1955. A method for obtaining sage grouse age and sex ratios from wings. Journal of Wildlife Management 19:267-272.

Johnsgard, P.A. 1980. The grouse of the world. University of Nebraska Press, Lincoln, Nebraska, USA.

Larson, J.S. and R.D. Taber. 1980. Criteria of sex and age. Pages 143-202 *in:* S.D. Schemnitz, editor. Wildlife management techniques manual. The Wildlife Society, Washington, DC, USA.

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RECENT COLLECTIONS OF EXOTIC AQUARIUM FISHES IN THE FRESHWATERS OF OREGON AND THERMAL TOLERANCE OF ORIENTAL WEATHERFISH AND PIRAPATINGA

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We report captures of exotic serrasalmine characids, *Piaractus brachypomus*, *P. mesopotamicus*, and an aberrant characid of unresolved identity and two species of cobitids, *Misgurnus mizolepis* and *M. anguillicaudatus* in freshwaters of Oregon. Oriental weatherfish, *M. anguillicaudatus*, appear to be established in a localized area of the Clackamas River of western Oregon, and in the Owyhee, Malheur, and Snake rivers of eastern Oregon. Preliminary thermal tolerance testing of pirapatinga, *P. brachypomus*, and oriental weatherfish showed that the former was unlikely to survive winter water temperatures in temperate western states, whereas the latter could easily tolerate water temperatures lower than normal winter temperatures.

INTRODUCTION

Exotic fishes have been part of Oregon's fauna for over a century. Lampman (1946) documented many of these introductions, which were made by various government agencies for the presumed benefit of the region. More recently, we have found evidence of intentional release of unwanted aquarium fishes. Although the release of tropical aquarium fishes is usually not considered a risk in temperate climates, we became concerned because of recent multiple captures of some species and because, until recently, the State of Oregon prohibited possession of any serrasalmine characid, a taxon captured repeatedly in recent years. Our purpose is to report recent collections of Cobitidae and Characidae (Serrasalminae) from Oregon, to document preliminary chronic and acute thermal tolerance for oriental weatherfish, *Misgurnus anguillicaudatus*, and pirapatinga, *Piaractus brachypomus*, and to relate those results to annual water temperature cycles in the Willamette, Snake, and Sacramento rivers.

METHODS

Collections

Representative specimens are deposited in the Oregon State University Fish Collection (OS). Collection information is presented with each species account. All lengths are recorded as standard length. Where available, we use the common names

applied to these fishes by Robins et al. (1991) or Axelrod et al. (1985).

Thermal Tolerance

For the thermal tolerance studies, 22 oriental weatherfish (7.6-16.2 cm total length, 2.2-17.8 g) were collected on 2 November 1991 from the Clackamas County, Oregon site and 60 pirapatinga (7.0-11.4 cm fork length, 8.5-41.6 g) were obtained from a tropical fish dealer. The oriental weatherfish were acclimatized at 18-20°C for 6 months. The pirapatinga were acclimatized at 25°C for 10 d to allow for recovery from transportation stress (Kindle and Whitmore 1986). Commercial pellet fish food was weighed and fed to pirapatinga twice daily and to oriental weatherfish weekly.

For chronic experiments, we used two replicates and a control tank maintained at the acclimation temperature. Each 76-liter replicate tank (tanks A and B) had 15 pirapatinga or seven oriental weatherfish, a box filter, aerator, and a power head that pumped chilled water from a reservoir tank, partitioned so that water for each replicate was separate. A 12-h light, 12-h dark photoperiod was maintained for all experiments (Penney and Goldspink 1981, Kindle and Whitmore 1986). Water temperature was lowered by 2°C every day until a temperature of 2°C was attained (oriental weatherfish) or by 2°C on alternate days until all fish were dead (LT_{100}) (pirapatinga). Death was defined to occur when all external movement had ceased (Becker and Genoway 1979, Duodoroff 1942). If fish survived to 2°C, they were held for 3-11 d at this temperature.

The acute experiments for oriental weatherfish consisted of transfer of eight fish from 18°C to 6°C and seven fish from 6°C to 18°C (the latter had also been subjected to the chronic experiment). The acute experiment for pirapatinga consisted of transfer of four fish each from 25°C to test temperatures of 10, 12, 14, 15, and 16°C, and a control transfer to 25°C (none of these fish had been exposed to chronic thermal stress). Fish reactions were monitored for up to 4 h. Total loss of equilibrium was defined to occur when a fish was on its side on the bottom of the tank and stayed down for the duration of the experiment (maximum 4 h). Re-acclimation was attempted after 4 h by placing fish that had experienced a total loss of equilibrium back into 25°C water.

Representative annual river water temperature cycles were obtained from the Water Resources Division of the U.S. Geological Survey for the Willamette River, at Albany, Oregon (T11S, R4W, Sec. 1, NW ¼) (1984-1988); for the Snake River, at Weiser, Idaho (T11N, R5W, Sec. 31, SE ¼) (1975-1981); and for the Sacramento River at Freeport, California (T7N, R4E, Sec. 13, SW ¼) (1991-1994).

RESULTS

Collections

Chinese fine-scaled loach, *Misgurnus mizolepis* (Fig. 1A and 3)

OS 08671; one specimen (135 mm); Oregon, Baker County; T9S, R40E, Sec. 20; 44° 46' 48" N, 117° 50' 24" W; Day irrigation canal, Powder River, Snake River

Drainage; 25 May 1977; collected by D. West using a backhoe.

The first cobitid collected in Oregon appears to have been a Chinese fine-scaled loach, but the taxonomy of this group is unsatisfactory. Our identification is based on Nichols' (1943) key and should be considered tentative. M. Kottelat (Cornol, Switzerland, pers. comm.) also tentatively identifies the specimen as *M. mizolepis* following Rendahl (1934) rather than Chen (1981) who treats *M. mizolepis* as a synonym of *M. anguillicaudatus*. The single specimen was collected under 15 cm of gravel (D. West, Oregon Department of Fish and Wildlife [ODFW], pers. comm.). The collection site, Day irrigation canal, which drained into the Powder River, was permanently dewatered soon after the collection of the specimen in 1977. On 17 May 1995 we surveyed Elk Creek, the first tributary of Powder River upstream of Day irrigation canal, and an unnamed irrigation canal, the first downstream tributary of Powder River, without collecting specimens of Chinese fine-scaled loach. No additional specimens of Chinese fine-scaled loach have been reported from Oregon or elsewhere in North America.

Oriental weatherfish, *Misgurnus anguillicaudatus* (Fig. 1B and 3).

Western Oregon: OS 13196, OS 13215, and OS 13216; 56 specimens (12.5-140 mm); Oregon, Clackamas County; T2S, R2E, Sec. 12; 44° 25' N, 122° 35' W; unnamed pond at Brownell Holly Farm, Clackamas River, Willamette River Drainage; 10 and 17 August 1991; collected by D. and C. Logan with an electrofisher.

Eastern Oregon: OS 15467; 11 specimens (39-127 mm); Oregon, Malheur County; T21S, R46E, Sec. 2; 43° 45' N, 117° 04' W; unnamed irrigation canal, Owyhee River, Snake River Drainage; 18 May 1995; collected by D. Logan and B. Jonsson with an electrofisher. OS 15473; six specimens (79-148 mm); Oregon, Malheur County; T8N, R5W, Sec. 6; 44° 04' N, 117° 00' W; Canyon Number 1, Snake River, Columbia River Drainage; 18 May 1995; collected by D. Logan and B.

Figure 1. Left lateral views of: A. Chinese fine-scaled loach, *Misgurnus mizolepis*, OS 8671, 135 mm SL; and B. oriental weatherfish, *Misgurnus anguillicaudatus*, OS 13196, 85.7 mm SL. Photographed by D. Markle, December 1993.

Jonsson with an electrofisher. OS 15474; eight specimens (76-153 mm); Oregon, Malheur County; T8N, R5W, Sec. 31; 44° 03' N, 117° 01' W; unnamed irrigation ditch, Malheur River, Snake River Drainage; 18 May 1995; collected by D. Logan and B. Jonsson with an electrofisher.

The senior author first observed specimens of oriental weatherfish at the Clackamas site in 1985, but specimens were not saved until 1991. The habitat is a diked secondary channel of the Clackamas River that is connected directly to the river through a culvert during normal high-water events. The land within the dike is now used for agriculture and the resulting pond is used for irrigation. The habitat is approximately 1.3 km long and is generally shallow with an average depth < 1 m, though a trench is present where the maximum depth is about 2.5 m. The substrate is primarily cobble, which is also the dominant substrate in the Clackamas River near this site. The habitat margins are characterized by fine sediments, organic ooze, and submergent and emergent vegetation. In summer, water temperatures at some places in the pond may exceed 30°C, though springs are present and cooler Clackamas River water seeps through the dike. Water levels of the pond in summer may be low because of evaporation and irrigation. In some winters, the pond has an ice cover for several weeks.

The specimens were generally found in shallow (<20 cm) water with either thick muddy sediments and dense vegetation or with cobble substrates. Oriental weatherfish, especially juveniles, were abundant but difficult to capture with electrofishing because of the complex habitat and the fishes' escape abilities.

Native fishes co-occurring with oriental weatherfish at this site were mountain whitefish, *Prosopium williamsoni*; rainbow trout, *Oncorhynchus mykiss*; coho salmon, *Oncorhynchus kisutch*; northern squawfish, *Ptychocheilus oregonensis*; redside shiner, *Richardsonius balteatus*; speckled dace, *Rhinichthys osculus*; and prickly sculpin, *Cottus asper*. Other exotic fishes captured at this site were largemouth bass, *Micropterus salmoides*; bluegill, *Lepomis macrochirus*; common carp, *Cyprinus carpio*; and brown bullhead, *Ameiurus nebulosus*.

The Owyhee River site (OS 15467) is an irrigation canal, approximately 400 m long, with an average depth of about 1 m, that connects indirectly to the Owyhee River. Water levels in the canal fluctuate and may have been low because of evaporation and irrigation. The irrigation canal drain is controlled by a manually operated screw gate. The land surrounding the canal is used for agriculture. The substrate is primarily fine sediments and organic ooze with anthropogenic debris present; submergent and emergent vegetation is common. In winter the canal has an ice cover for several weeks. Oriental weatherfish were found in shallow (<40 cm) water with thick, muddy sediments, dense vegetation, or much anthropogenic debris. Native tui chub, *Gila bicolor*, and redside shiner and exotic bluegill and common carp also were collected at this site.

The Snake River site (OS 15473) is a perennially watered, highly modified tributary of the Snake River used for irrigation. Although the dominant land use in the drainage area is agriculture, the land surrounding the collection site is developed with parking lots and buildings. We surveyed approximately 50 m of the stream; the

habitat had an average depth of less than 50 cm. The substrate is primarily fine sediments with submergent and emergent vegetation present, though patchy. Vegetation is controlled mechanically to facilitate irrigation. Winter temperatures are moderated by seeps, though ice cover is common. Oriental weatherfish were collected in shallow (<30 cm) water with thick muddy sediments and sparse vegetation. No other fishes were collected at this site. Many weatherfish have been collected at this site by Owyhee Irrigation District (OID) personnel (J. Melvin, OID, pers. comm.).

The Malheur River site (OS 15474) is a perennially watered, shallow (<50 cm) irrigation canal that drains indirectly into the Malheur River. We surveyed approximately 25 m of the canal below a 4-m drop and 15 m above the drop. The substrate is primarily fine sediments with submergent and emergent vegetation present, though uncommon. Vegetation is controlled manually to facilitate irrigation. Winter temperatures are moderated by seeps making areas in the canal ice free. We collected oriental weatherfish in shallow (<30 cm) water with thick muddy sediments and sparse vegetation only below the drop. Exotic fathead minnow, *Pimephales promelas*, previously undocumented from Malheur County, was the only other species captured at this site. Many specimens of weatherfish have been collected above and below the drop at this site by OID personnel (R. Perkins, ODFW, pers. comm.).

Tambaqui or blackfin pacu, *Colossoma macroponum*? (Fig. 2A and 3)

or

Pirapatinga or red-bellied pacu, *Piaractus brachypomus*?

OS 13217; one specimen (408 mm); Oregon, Malheur County; T8N, R5W, Sec. 33; 44° 03' N, 116° 58' W; Snake River at Ontario State Park; 19 July 1991; hook and line capture. The name of the collector was not reported.

This specimen appears to be atypical and its identification is unresolved. P. Petry (Instituto Nacional de Pesquisas da Amazônia [INPA], Manaus, Brazil) examined this specimen and noted that it possessed a rayed adipose fin and counter-shading consistent with tambaqui, but body shape and gill raker counts consistent with pirapatinga. Petry tentatively identified the specimen as a tambaqui, but noted that it may be a hybrid. The specimen was examined by L. Nico (National Biological Service [NBS], Gainesville, Florida), as well. Nico noted that body shape, dentition, and scale and gill raker counts of the specimen were consistent with pirapatinga and that the unusual color pattern was of minor consideration. Nico concluded that the specimen was a pirapatinga and probably not a hybrid.

Many recently-caught serrasalmines in Oregon have generated considerable local coverage by the news media, which frequently call them piranhas. This specimen was the subject of radio and news reports in the Malheur County area and the news reports led a local woman to phone ODFW to explain the circumstances of release. The fish apparently belonged to her husband, who had recently died. Instead of sacrificing the fish, she released it during the summer of 1991.

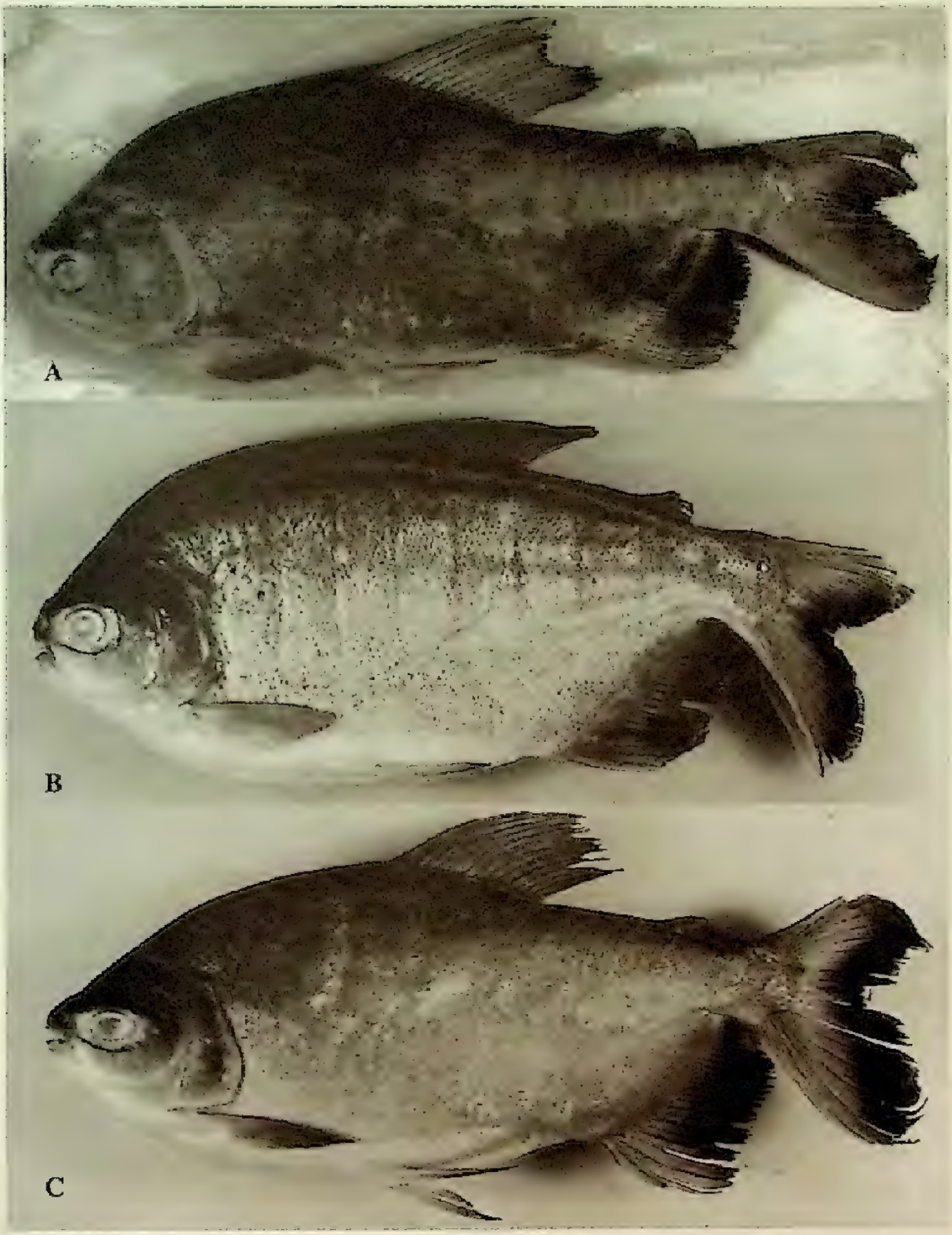

Figure 2. Left lateral views of: A. aberrant characid — tambaqui or blackfin pacu, *Colossoma macropomum*, or pirapatinga or red-bellied pacu, *Piaractus brachypomus*, OS 13217, 408 mm SL; B. caranha, *Piaractus mesopotamicus*, OS 11983, 238 mm SL; and C. pirapatinga or red-bellied pacu, *Piaractus brachypomus*, OS 11491, 201 mm SL. Photographed by D. Markle, December 1993.

Caranha, *Piaractus mesopotamicus*, (Fig. 2B and 3)

OS 11983; one specimen (238 mm); Oregon, Douglas County; T30S, R5W, Sec. 26; 42° 56' N, 123° 15' W; Herbert's Pond, 1.6 km east of Canyonville, Umpqua River; 21 July 1989; collected by M. Atherton; collecting gear not reported.

Pirapatinga or red-bellied pacu, *Piaractus brachypomus* (Fig. 2C and 3)

OS 11491, one specimen (201 mm); Oregon, Multnomah County; T1N, R1W, Sec. 2; 45° 37' N, 122° 47' W; Willamette River at Port of Portland Terminal No. 4, river km 6.4, near grain elevators; 4 July 1988; collected with hook and line by R. Simon.

The stomach of this specimen contained wheat grains, a crayfish, and an earthworm (bait), typical items for omnivorous serrasalmines (Goulding 1980, Goulding and Carvalho 1982).

Four additional specimens of *Piaractus* have been caught recently in Oregon, identified with varying degrees of certainty, but not deposited in museums. A specimen, tentatively identified as a pirapatinga, was collected near the Hood River Bridge on the Columbia River on 29 September 1990 by T. Brigham who was using a gill net. Water temperature of the Columbia River at Bonneville Dam was 20.5°C on the day of capture. A specimen from a pond in Salem, Oregon in 1991 was reported to us without further data or confirmation of identification. A pirapatinga, 295 mm, was collected at Monroe, Benton County, Oregon on the Long Tom River, Willamette Drainage on 3 August 1992 by B. Howell who was using earthworms for bait. A pirapatinga, 350 mm, was collected at Sellwood Park Pond, Portland, Oregon at river km 26.7 on the Willamette River on 1 August 1995 by P. Weaver who also was using earthworms for bait.

Thermal Tolerance

Oriental weatherfish

No oriental weatherfish died during thermal tolerance testing. In the chronic test, fish movements were noticeably slower and no foraging occurred at temperatures <8°C; prodding was necessary to elicit movement at 2°C. Thermal challenge of 18°C to 6°C also resulted in slower movements, no foraging, and no feeding. Within 24 h, fish challenged from 6°C to 18°C were active and feeding.

Pirapatinga

In the chronic thermal tolerance study, fish from both replicates ceased eating on the 9th d of the experiment at temperatures of 17.5°C and 17.0°C. The LT_{50} was 11.5°C and the LT_{100} was 9°C for data pooled from both replicates.

In the acute thermal tolerance study, control fish exhibited no loss of equilibrium. At all other temperatures, equilibrium was lost; equilibrium was lost faster at lower temperatures. At 10°C, all fish lost equilibrium and were flat on their sides on the bottom within 3 min. Fish at 12°C and 14°C underwent lateral arching of the body into a "C" shape prior to loss of equilibrium. Fish at 12°C had a total loss of equilibrium by 14 min, 20 s and fish at 14°C lost equilibrium by 80 min, 30 s. At

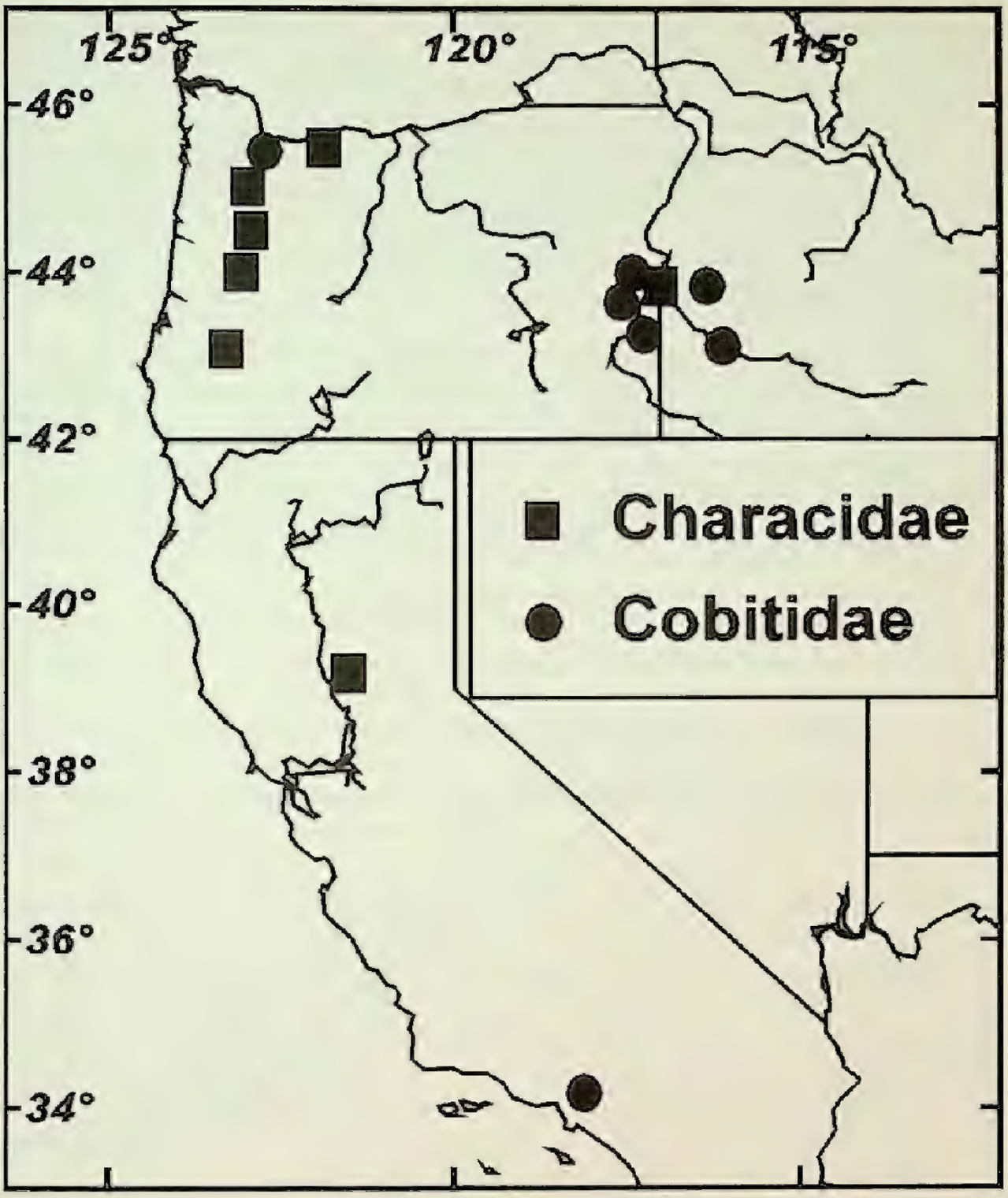

Figure 3. Distribution records of characids and cobitids in western United States.

15°C, only two fish underwent C-arching and at 16°C, one of four fish C-arched. The fish in the 15°C and 16°C tanks exhibited escape behavior and erratic swimming in the corners and along the sides of the aquarium. After 4 h (end of the experiment), the fish at 15°C recovered. Fish at 16°C showed some loss of equilibrium by 9 min, but no fish ever lost all equilibrium and all recovered by 2 h, 19 min.

Revival from 4-h acute thermal shock varied with temperature. One fish at 10°C

appeared dead, but began opercular movement within 2 min of being placed in 25°C water. In 14 min this fish was swimming. The other three fish from the 10°C experiment never ceased opercular movement for the 4-h observation period. One fish was swimming within 37 s of being placed in 25°C water, but the other two never recovered and died overnight. The fish at 12°C were all swimming within 40 s, but did not achieve equilibrium for 13 min, 26 s and continued to respire heavily. At 14°C fish were all upright in 8 s, and appeared normal by 4 min, 5 s. At least one fish at 10°C was feeding on the day after treatment and two fish each from 12°C and 14°C were feeding later the same day. Fish at 15°C and 16°C recovered during the 4 h of the treatment.

Average minimum temperatures for the Willamette, Snake, and Sacramento rivers were below the LT_{50} and LT_{100} for pirapatinga for some months (Fig. 4). The overall lowest minimum temperature for the Willamette River was 3.7°C, and the overall highest minimum was 19.3°C. On the Snake River the lowest minimum temperature was 0°C and the highest minimum was 25°C. Minimum temperatures of the Sacramento River tended to be higher, ranging from 8.6°C in January to 23.5°C in August.

DISCUSSION

Cobitidae

The native distribution of Chinese fine-scaled loach is southern and eastern China (Nichols 1943) and south into northern Southeast Asia (Axelrod et al. 1985). Considering that only a single specimen of Chinese fine-scaled loach has been recovered from Oregon, it is unlikely that the species is established; the 1977

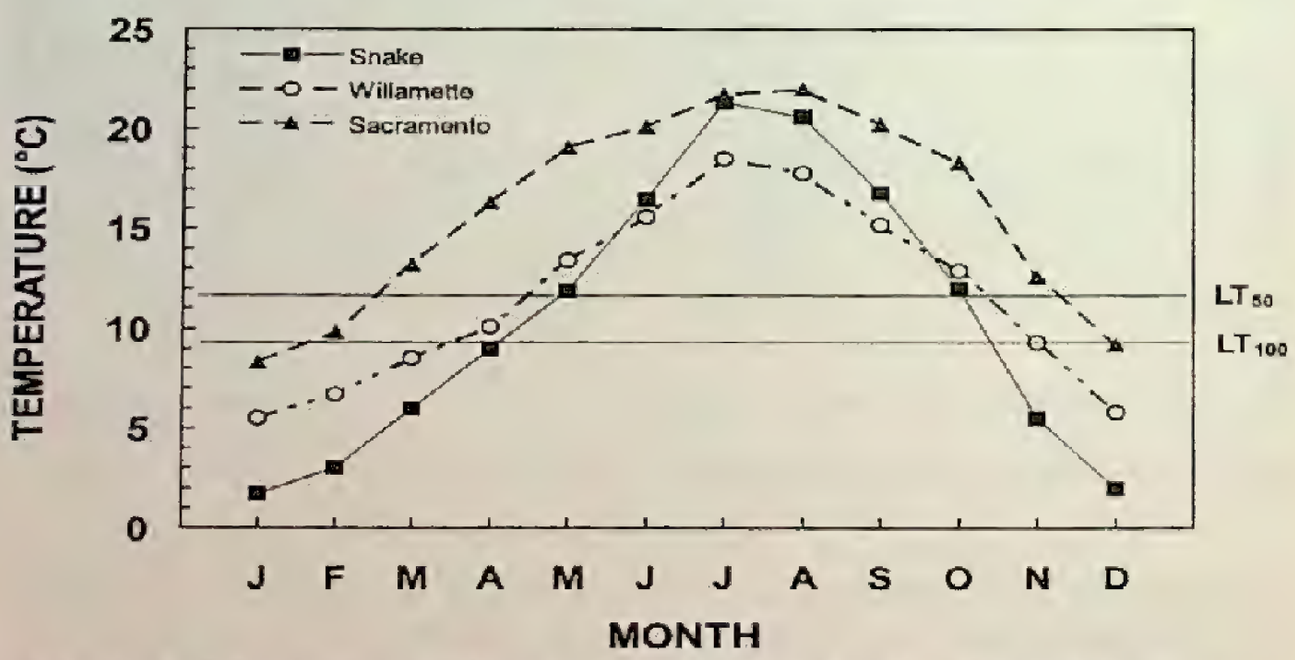

Figure 4. Average minimum monthly temperature for the Willamette River at Albany, Oregon, 1984-1988, the Snake River at Weiser, Idaho, 1975-1981, and the Sacramento River at Freeport, California, 1992-1994. The LT_{50} and LT_{100} values from the chronic thermal study of pirapatinga are superimposed. Months are abbreviated with the first letter of the month from January to December.

collection probably represents the fortuitous collection of a discarded aquarium fish.

The native distribution of oriental weatherfish covers at least 20° to 50° north latitude and includes Thailand (Masuda et al. 1984); southeastern Russia; much of China, including Hainan; Japan; Korea; Taiwan; Viet Nam; and Burma (Berg 1949). This range of distribution would potentially allow weatherfish to become established in many areas of southern Canada, the United States, and Mexico.

Established populations of oriental weatherfish are reported in the United States from Michigan (Schultz 1960), California (St. Amant and Hoover 1969), Illinois (Page and Laird[1] 1993), Hawaii (Maciolek 1984), Idaho (University of Idaho, UI 1464; Courtenay et al. 1987), and a population of questionable status in Florida (J. Williams, NBS, Gainesville, Florida, pers. comm.). Exotic populations of oriental weatherfish are also established in Mexico (Contreras and Escalante 1984), Australia (Burchmore et al. 1990), Palau (Maciolek 1984), and the Philippines (Welcomme 1984).

Oriental weatherfish have several biological characteristics typical of successful exotic species (Taylor et al. 1984): (i) broad tolerances for physiological parameters, as demonstrated by a capacity for intestinal air breathing (McMahon and Burggren 1987) and our thermal tolerance experiments; (ii) a flexible diet (Hensley and Courtenay 1980, Watanabe and Hidaka 1983); (iii) low vulnerability to predation due to their fossorial habits; and (iv) high reproductive potential (Suzuki 1983). Utilitarian benefit (the pet trade) should also be considered an additional characteristic for a successful invader species. Utilitarian benefit does not specifically facilitate success in a novel environment, but does facilitate movement of species. Oriental weatherfish may also live long, as some of Suzuki's (1983) laboratory-reared fish were 10 yr old.

Evidence regarding the ability of weatherfish to disperse is equivocal, but suggests that their dispersal is facilitated by flood control and irrigation systems. Rapid range expansion of exotic populations in natural drainages is only documented in Australia (Burchmore et al. 1990, Lintermans et al.[2] 1990, Lintermans[3] 1993). Weatherfish were banned from Australia in 1986 (Burchmore et al. 1990). Work in Michigan in 1987 suggests that oriental weatherfish had not dispersed widely since their first appearance in 1958 (W. Latta, Michigan Department of Natural Resources [MDNR], pers. comm.), although they have unconstrained access to other areas. In

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[1] Page, L.M. and C.A. Laird. 1993. The identification of the nonnative fishes inhabiting Illinois waters. Center for Biodiversity Technical Report 1993(4):1-39. Illinois Natural History Survey, Champaign, Illinois, USA.

[2] Lintermans, M., T. Rutzou, and K. Kukolic. 1990. The status, distribution and possible impacts of the oriental weatherloach *Misgurnus anguillicaudatus* in the Ginninderra Creek catchment. Australian Capital Territory Parks and Conservation Service, Research Report 2. Tuggeranong, Australian Capital Territory, Australia.

[3] Lintermans, M. 1993. Oriental weatherloach *Misgurnus anguillicaudatus* in the Cotter River: a new population in the Canberra region. Australian Capital Territory Parks and Conservation Service, Technical Report 4. Tuggeranong, Australian Capital Territory, Australia.

California, weatherfish were first collected in the Westminster Channel, one of a complex of modified flood control channels in Orange County (Swift et al. 1993, St. Amant and Hoover 1969). A subsequent 1977 survey in the Westminster Channel discovered weatherfish farther upstream than during the original survey and a 1979 survey discovered them in the adjoining Bolsa Chica Channel (Shapovalov et al. 1981; F. Hoover, California Department of Fish and Game [CDFG], pers. comm.). This flood control channel system has no access to open water and further dispersal is restricted by intermittent flow to the east and marine tidal influence to the west (St. Amant and Hoover 1969). In the lower Boise River drainage of Idaho, weatherfish are routinely reported in various irrigation canals (D. Allen, Idaho Department of Fish and Game [IDFG], pers. comm.). Weatherfish have been recorded from irrigation canals near Nampa, Idaho, in the Snake River drainage, as well (R. Scarpella, IDFG, pers. comm.). Our data show weatherfish are widely distributed in irrigation canals in the Malheur, Owyhee, and Snake river drainages of eastern Oregon. We do not know if all Snake River drainage irrigation canal populations, including Boise, Malheur, and Owyhee rivers, are the result of single or multiple releases, but their proximity (Fig. 3) suggests that some aspect of canal systems may facilitate dispersal.

Oriental weatherfish could be predators on native fishes or parasite and disease vectors. In aquaria, we observed oriental weatherfish consume live fry of mosquitofish, *Gambusia affinis*, and commercially prepared salmon egg fishing bait. Lintermans et al.[2] (1990) list three digenean trematodes, *Echinostoma cinetorchis*, *E. hortense*, and *Clinostomum complanatum*, and the viral pathogen birnavirus LV-1 from weatherfish. Birnavirus LV-1 is related to Infectious Pancreatic Necrosis Virus, a major disease of salmonids (Wolf 1988).

Characidae (Serrasalminae)

Pacus are tropical South American fishes from the Amazon, Orinoco, and La Plata river basins (Machado-Allison 1982). It is unlikely that fishes from tropical South America would become established in temperate North America. Shafland and Foote (1979) document that redeye piranha, *Serrasalmus rhombeus* (originally identified as *S. humeralis*), became established in subtropical Dade County, Florida. The species was stocked in a sinkhole pool at a tourist attraction in the early 1960s and was extirpated with the use of rotenone in 1977.

All of the serrasalmine captures in Oregon have been between 4 July and 29 September, with most in July. These are 3 of the 4 warmest months for most waters in the state (Fig. 4). Our data on the LT_{50} suggest that the pirapatinga, at least, and probably most serrasalmines, would not survive normal water temperatures found from November to April in Oregon or December to February in California (Fig. 4). However, elevated temperatures in some areas, such as natural warm springs or power plant effluents, create conditions that may facilitate local establishment.

Some aspects of our preliminary experiments might incorrectly estimate the thermal capabilities of serrasalmines. Although we found no relationship between

pirapatinga weight and temperature at death, we used small (<120 mm, <42.0 g) specimens that might have a narrower thermal tolerance than the larger fish (>200 mm) typically collected in Oregon. Our chronic experiment simulated a much faster temperature drop than naturally occurs. A more natural rate of decline (about 0.08-0.14°C per d) might allow acclimation to temperatures lower than we estimate, but it seems unlikely that they could acclimate to 4-6°C water. Finally, we note that pirapatinga can tolerate a drastic direct change in water temperature. The fish had relatively little trouble when moved from 25°C into 16°C water. However, feeding stopped at about 17°C in the chronic experiment and equilibrium was lost at 15°C in the acute experiment, suggesting that these temperatures are near the limit for successful prey capture and predator avoidance.

Results from our thermal tolerance studies for pirapatinga were similar to the thermal tolerances for redeye piranha. Shafland and Foote (1979) used specimens taken from the Dade County, Florida population of redeye piranha and subjected them to a thermal challenge of 1°C decrease in water temperatures per day until death of the fish. Those authors reported that redeye piranha lost equilibrium at 12-14°C and that all specimens died by 11°C. The Dade County population of redeye piranha survived the winter of 1976-1977, one of the coldest winters on record.

Collections of pacus are not unique to Oregon. Courtenay et al. (1984) list pacu collections from Arizona, California, Missouri, Ohio, and Georgia. Additionally, pacus have been recorded from Alabama (University of Florida Museum of Natural History, uncatalogued), Arkansas (Wright[4] 1995), Hawaii (Devick 1991), Illinois (Southern Illinois University Ichthyological Museum - SIUC 19835), Kentucky (SIUC 22241), Massachusetts (Cardoza et al. 1993), Mississippi (University of Mississippi Ichthyological Museum - USM 14134, USM 14160, USM 14637), Pennsylvania (Courtenay et al. 1991), Texas (Howells et al.[5] 1991), and Virginia (Bohn[6] 1988). Undocumented accounts of collections of pacus have been reported from Louisiana, New York, North Carolina, and Washington (NBS, nonnative fish database, Gainesville, Florida).

Brittan and Grossman (1979) document the collection of tambaqui from the Sacramento River (listed as *C. nigripinnus*, but see Machado-Allison 1982 for synonomy of *C. macroponum*). Using our LT_{50} data for pirapatinga and thermal data from the Sacramento River (Fig. 4), we infer that it is unlikely that pacus would survive typical winters in northern California. In typical years, daily minimum temperatures in the Sacramento River are below 15°C from November through March. Brittan and Grossman (1979) state that 18°C is the approximate minimum temperature at which most tropical lowland fishes can maintain themselves. Daily

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[4] Wright, S. 1995. Piranha or pacu - it's still a whale of a fish tale. Northwest Arkansas Times (Fayetteville), 7 June 1995, 129(350):B6.

[5] Howells, R.G., R.L. Benefield, and J.M. Mambretti. 1991. Records of pacus (*Colossoma* spp.) and piranhas (*Serrasalmus* spp.) in Texas. Texas Parks and Wildlife, Management Data Series 70. Austin, Texas, USA.

[6] Bohn, J. 1988. Toothy fish puts the bite on Burke Lake angler. Washington Post, 4 June 1988, G1, G3-4. Washington DC, USA.

average minimum water temperatures in the Sacramento River are above 18°C from May through October, though the existence of areas of increased water temperatures, such as natural or anthropogenic discharges, may facilitate local establishment.

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LITERATURE CITED

Axelrod, H.R., W.E. Burgess, N. Pronek, and J.G. Walls. 1985. Dr. Axelrod's atlas of freshwater aquarium fishes. T.F.H. Publications, Inc., Neptune City, New Jersey, USA.

Becker, C.D. and R.G. Genoway. 1979. Evaluation of the critical thermal maximum for determining thermal tolerance of freshwater fish. Environmental Biology 4:245-256.

Berg, L.S. 1949. Freshwater fishes of the U.S.S.R. and adjacent countries, Volume II, 4th edition. Israel Program for Scientific Translation, Jerusalem, Israel.

Brittan, M.R. and G.D. Grossman. 1979. A pacu (*Colossoma*, Family Characidae) caught in the Sacramento River. California Fish and Game 65:170-173.

Burchmore, J., R. Faragher, and G. Thorncraft. 1990. Occurrence of the introduced oriental weather loach (*Misgurnus anguillicaudatus*) in the Wingecarribee River, New South Wales. Pages 38-46 *in*: D.A Pollard, editor. Introduced and translocated fishes and their ecological effects. Australian Society for Fish Biology Workshop, Bureau of Rural Resources, Proceedings No. 8. Australian Government Publishing Service, Canberra Province, Australia.

Cardoza, J.E., G.S. Jones, T.W. French, and D.B. Halliwell. 1993. Exotic and translocated vertebrates of Massachusetts, 2nd edition. Fauna of Massachusetts Series No. 6, publication number 17223-110-200-11/93-C.R. Massachusetts Division of Fisheries and Wildlife, Westborough, Massachusetts, USA.

Chen, J. 1981. A study on the classification of the subfamily Cobitinae of China. Transactions of the Chinese Ichthyological Society 1:21-32 (in Chinese, citation not seen).

Contreras, S. and M.A. Escalante. 1984. Distribution and known impacts of exotic fishes in Mexico. Pages 102-130*in*: W.R. Courtenay, Jr. and J.R. Stauffer, Jr., editors. Distribution, biology, and management of exotic fishes. Johns Hopkins University Press, Baltimore, Maryland, USA.

Courtenay, W.R., Jr., D.A. Hensley, J.N. Taylor, and J.A. McCann. 1984. Distribution of exotic fishes in the continental United States. Pages 41-77 *in*: W.R. Courtenay, Jr. and J.R. Stauffer, Jr., editors. Distribution, biology, and management of exotic fishes. Johns Hopkins University Press, Baltimore, Maryland, USA.

Courtenay, W.R., Jr., D.P. Jennings, and J.D. Williams. 1991. Appendix 2: Exotic fishes. Pages 97-107 *in*: C.R. Robins, R.M. Bailey, C.E. Bond, J.R. Brooker, E.A. Lachner, R.N. Lea, and W.B. Scott, editors. Common and scientific names of fishes from the United States and Canada, 5th edition. American Fisheries Society, Special Publication 20, Bethesda, Maryland, USA.

Courtenay, W.R., Jr., C.R. Robins, R.M. Bailey, and J.E. Deacon. 1987. Records of exotic fishes from Idaho and Wyoming. Great Basin Naturalist 47:523-526.

Devick, W.S. 1991. Patterns of introductions of aquatic organisms to Hawaiian freshwater habitats. Pages 189-213 *in*: New Directions in Research, Management and Conservation of Hawaiian Freshwater Stream Ecosystems. Proceedings of the 1990 Symposium on Freshwater Stream Biology and Fisheries Management, Division of Aquatic Resources, Hawaii Department of Land and Natural Resources, Honolulu, Hawaii, USA.

Doudoroff, P. 1942. The resistance and acclimatization of marine fishes to temperature changes, I. Experiments with *Girella nigricans*. Biological Bulletin 83:219-244.

Goulding, M. 1980. The fishes in the forest: Explorations in Amazonian natural history. University California Press, Berkeley, California, USA.

Goulding, M. and M.D. Carvalho. 1982. Life history and management of the tambaqui (*Colossoma macropomum*, Characidae): an important Amazonian food fish. Revia Brasilia Zoologica 1:107-133.

Hensley, D.A. and W.R. Courtenay, Jr. 1980. Oriental weatherfish. Page 436 *in*: D.S. Lee, C.R. Gilbert, C.H. Hocutt, R. E. Jenkins, D.E. McAllister, and J.R. Stauffer, Jr., editors. Atlas of North American freshwater fishes. Publication No. 1980-12 of the North Carolina Biological Survey, Raleigh, North Carolina, USA.

Kindle, K.R. and D.H. Whitmore. 1986. Biochemical indicators of thermal stress in *Tilapia aurea*. Journal of Fish Biology 29:243-255.

Lampman, B.H. 1946. The coming of the pond fishes. Binfords and Mort Publishers, Portland, Oregon, USA.

Machado-Allison, A. 1982. Estudios sobre la subfamilia Serrasalminae (Teleostei, Characidae), Parte 1, Estudio comparado de los juveniles de las "cachamas" de Venezuela (generos *Colossoma y Piaractus*). Acta Biologica Venezuelica 11:1-101.

Maciolek, J.A. 1984. Exotic fishes in Hawaii and other islands of Oceania. Pages 131-161 *in*: W.R. Courtenay, Jr. and J.R. Stauffer, Jr., editors. Distribution, biology, and management of exotic fishes. The Johns Hopkins University Press, Baltimore, Maryland, USA.

Masuda, H., K. Amaoka, C. Araga, T. Uyeno, and T. Yoshino. 1984. The fishes of the Japanese archipelago, Volume 1. Tokai University Press, Tokyo, Japan.

McManhon, B.R. and W.W. Burggren. 1987. Respiratory physiology of intestinal air breathing in the teleost fish *Misgurnus anguillicaudatus*. Journal of Experimental Biology 133:371-393.

Nichols, J.T. 1943. The fresh-water fishes of China. Natural history of Central Asia. Volume IX. American Museum of Natural History, New York, New York, USA.

Penney, R.K. and G. Goldspink. 1981. Short term temperature acclimation in myofibrillar ATPase of a stenotherm *Salmo gairdneri* Richardson and an eurytherm *Carassius auratus*. Journal of Fish Biology 18:715-721.

Rendahl, H. 1934. Untersuchungen ueber die chinesischen formen der Gattung *Misgurnus*. Acta Zoologica Fennica 16:1-32 (citation not seen).

Robins, C.R., R.M. Bailey, C.E. Bond, J.R. Brooker, E.A. Lachner, R.N. Lea, and W.B. Scott. 1991. World fishes important to North Americans. American Fisheries Society Special Publication 21, Bethesda, Maryland, USA.

Schultz, E.E. 1960. Establishment and early dispersal of a loach, *Misgurnus anguillicaudatus* (Cantor), in Michigan. Transactions of the American Fisheries Society 89:376-377.

Shafland, P.L. and K.J. Foote. 1979. A reproducing population of *Serrasalmus humeralis* Valenciennes in southern Florida. Florida Scientist 42:206-214.

Shapovalov, L., A.J. Cordone, and W.A. Dill. 1981. A list of the freshwater and anadromous fishes of California. California Fish and Game 67:4-38.

St. Amant, J.A. and F.G. Hoover. 1969. Addition of *Misgurnus anguillicaudatus* (Cantor) to the Californian fauna. California Fish and Game 55:330-331.

Suzuki, R. 1983. Multiple spawning of the cyprinid loach, *Misgurnus anguillicaudatus*. Aquaculture 31:233-243.

Swift, C.C., T.R. Haglund, M. Ruiz, and R.N. Fisher. 1993. The status and distribution of the freshwater fishes of Southern California. Bulletin of the Southern California Academy of Sciences 92:101-167.

Taylor, J.N., W.R. Courtenay, Jr., and J.A. McCann. 1984. Known impacts of exotic fishes in the continental United States. Pages 322-373 *in*: W.R. Courtenay, Jr. and J.R. Stauffer, Jr., editors. Distribution, biology, and management of exotic fishes. The Johns Hopkins University Press, Baltimore, Maryland, USA.

Watanabe, K. and T. Hidaka. 1983. Feeding behavior of the Japanese loach, *Misgurnus anguillicaudatus* (Cobitidae). Journal of Ethology 1:86-90.

Welcomme, R.L. 1984. International transfers of inland fish species. Pages 22-40 *in*: W.R. Courtenay, Jr. and J.R. Stauffer, Jr., editors. Distribution, biology, and management of exotic fishes. The Johns Hopkins University Press, Baltimore, Maryland, USA.

Wolf, K. 1988. Fish viruses and fish viral diseases. Comstock Publishing Associates, Ithaca, New York, USA.

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AGE AND PATHOLOGICAL FINDINGS FOR TWO FEMALE STELLER SEA LIONS STRANDED ON THE NORTHERN CALIFORNIA COAST

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This report details the causes of death of two adult Steller sea lions, *Eumetopias jubatus*, stranded on the north coast of California. In California, as in other areas of their range, Steller sea lion abundance is declining for unknown reasons. Several theories, including death due to fishery interactions, commercial harvest, long-term environmental change, and nutritional stress have been proposed. The Steller sea lions in this report were multiparous-aged females that died from pneumonia. Both animals also had evidence of gunshot wounds.

INTRODUCTION

The Steller sea lion, *Eumetopias jubatus*, once ranged extensively throughout the North Pacific Ocean, breeding as far north as Herschel Island (69°N) and as far south as the California Channel Islands (33°N) (Bartholomew and Boolootian 1960). The Steller sea lion population in California was stable from 1927 to 1947, ranging from 4,884 to 6,148 animals (Bonnot and Ripley 1948). However, since 1950, the Californian Steller sea lion population has been declining. Bartholomew and Boolootian (1960) reported a decrease in the population inhabiting the Channel Islands from 1,000 in 1950 to 50 in 1960. Two pups were born on San Miguel Island in 1982, but no other births have been documented since (Stewart et al. 1993). In 1991, no Steller sea lions were reported there (Loughlin et al. 1992).

A possible cause of this reduction is the conflict between sea lions and fisheries. Alverson (1992), reviewing conflicts between commercial fisheries and Steller sea lions in Alaska, identified four primary causes for the Steller sea lion population decline: (i) nutritional deficiencies of young animals, (ii) indiscriminate shooting,

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(iii) by-catch in fishing gear, and (iv) authorized commercial harvests. However, none of these causal factors could be singled out as having been the most important in the population decline.

In contrast, modeling results suggest that the observed decline in Steller sea lion abundance in Alaska is either a result of long-term environmental change or a novel catastrophe and not due to short-term environmental stochasticity, historic pup harvest, or deterministic transient population behavior (Pascual and Adkison 1994).

Sources of adult mortality include drowning in nets, gunshot wounds, parasite infestations, bacterial infections, and predation (Loughlin et al. 1987). Natural mortality in adult Steller sea lions from California waters is poorly documented. Our report describes results of postmortem examinations on two adult female Steller sea lions recovered from the north coast of California by The Marine Mammal Center (TMMC).

METHODS

Two adult female Steller sea lions were recovered live and brought to TMMC for rehabilitation. Both animals died during treatment. Postmortem examinations and morphological measurements were performed and samples for histopathological study were collected and submitted to the Department of Pathology at the University of California, Davis. Ages were estimated from examination of left upper canines using an acid-etching technique (Lowry and Folk[2] 1987). Voucher skulls were deposited at the California Academy of Sciences, San Francisco, California (CAS 23005 and 23092). Measurements of the skulls were made following Scheffer (1958).

RESULTS

Animal SSL4 was captured on 20 December 1987 from a grassy plateau above Virgin Creek, Mendocino County (39° 25' N, 123° 49' W). The animal was lethargic, underweight, anorexic (would not eat offered fish), and moderately dehydrated; it had difficulty moving its hind quarters. Wheezing was noted in the dorsal quadrant of the right lung but no air sounds were noted in the ventral portion. The left lung was difficult to assess due to the animal's position and extreme lethargy. Several small, circular wounds in the upper lumbar region attributed to buckshot were noted during the initial veterinary evaluation. Treatment for severe respiratory congestion included antibiotics (gentocin and penicillin), steroids (dexamethasone and stanozolol), and respiratory inhalation therapy (acetyl cysteine). SSL4 died after 9 d in captivity. A severe pneumonia was noted during the postmortem examination; however, no etiology was identified. Contributory causes of death were advanced age and intestinal nematode and trematode infestations. No foreign bodies were

[2]Lowry, M. and R. Folk. 1987. Feeding habits of California sea lions from stranded carcasses collected at San Diego County and Santa Catalina Island, California. NMFS Administrative Report LJ-87-15.

recovered from this animal to confirm the suspected gunshot wounds. See Table 1 for skull and body measurements.

Animal SSL4 was 16 yr old. Unusual tooth wear, resulting in the upper third of the left upper canine being worn away, may have led to the loss of additional growth-layer groups.

Histopathological examination showed that the animal had uterine fibroleiomyoma and bilateral ovarian fibrosis mineralization, epithelial proliferation with cyst formation suggestive of ovarian sex cord stromal tumors, and nodular hyperplasia of the thyroid gland. Presence of neoplastic and hyperplastic lesions in this individual are consistent with an older animal, as the incidence of tumors increases with age (Misdorp 1990).

Animal SSL5 came ashore on a rocky beach at the base of a cliff at Sea Ranch, Sonoma County (38° 33' N, 123° 21' W) on 4 April 1989. The animal was admitted to TMMC on the same day, with severe respiratory congestion and lack of air movement in the left anterior quadrant of the thorax. Dehydration, emaciation, atrophy of the righteye, and healing wounds on the back were also noted. The animal was treated with antibiotics (tribrissen) and inhalation therapy (acetyl cysteine) for pneumonia, fluid therapy for maintenance hydration, and cimetidine hydrochloride for gastric ulcers. SSL5 died on 20 April, 16 d after admission. See Table 1 for skull and body measurements.

Table 1. Cranial, body, and age measurements of two Steller sea lions, SSL4 and SSL5, stranded on the northern California coast in 1987 and 1989.

Character	SSL4	SSL5
Interorbital width (mm)	40	48.5
Zygomatic width (mm)	180	169
Cranial width (mm)	123	127
Mandibular width (mm)	150	145
Condylobasal length (mm)	302	307
Basilar length of Hensel (mm)	276.5	277
Length of upper postcanine series (mm)	83	83.5
Notation of diastema and width (mm)	13.8	15.5
Standard length (cm)	211	198
Curvilinear length (cm)	228.5	217
Umbilical girth (cm)	103	107
Axillary girth (cm)	na	129.5
Anterior length of fore flipper (cm)	73.5	69
Widest fore flipper width (cm)	28	24
Anterior length of hind flipper (cm)	53.5	62
Widest hind flipper width (cm)	32	38
Weight at death (kg)	163.5	186
Estimated age (dental growth layer groups)	16	14

Postmortem examination revealed pneumonia of unknown etiology with consolidation in the left anterior lobe and fibrosis in both lungs, as well as several hemorrhagic gastric ulcers in the stomach. In addition to these findings, many shotgun pellets (2.88-3.46 mm) were found embedded around the cranium.

Examination of histopathological samples confirmed the proximate cause of death as severe, acute bronchopneumonia. Additional findings indicated a moderate endometritis, endometrial atrophy, and arteriole hypertrophy in the wall of the uterus. It was not determined whether this atrophy was due to a stage of the reproductive cycle or to reproductive senescence. The arteriolar changes resembled those described for postparturient uteri of a variety of mammals, indicating that this female was multiparous. SSL5 was 14 yr old.

DISCUSSION

Female Steller sea lions become sexually mature between age 3 and 8 yr (Perlov 1971, Pitcher and Calkins 1981). Mathisen et al. (1962) suggest that females may continue to breed into their early twenties, and Pitcher and Calkins (1981) suggest that they may live to be 30 yr old. A sample of 266 females incidentally taken in the walleye pollock fishery in Alaska, ranged from 1 to 25 yr, but only five individuals were older than 16 yr (Loughlin and Nelson 1986). Thus, the females in this report are old animals, although they had not reached maximum age. Also, female Steller sea lions in California may not live as long as their Alaskan counterparts.

Pneumonia, as found in these animals, in conjunction with parasites and debilitation, is a common cause of stranding and death of pinnipeds (Sweeney 1974, Howard et al. 1983, Gerber et al. 1993). Several studies of stranded California sea lions, *Zalophus californianus*, have found pneumonia, secondary to parasitic infection, to be the primary stranding cause (Sweeney and Gilmartin 1974, Gerber et al. 1993). Verminous pneumonia was the primary cause of death in two yearling Steller sea lions in Oregon, and three of the nine Steller sea lions in that study died from conditionsassociated with parasite infestations (Stroud and Roffe 1979). If nutritional stress is occurring in Steller sea lion populations, as indicated in Alaska (Loughlin and Merrick 1989, Alverson 1992), then fatalities associated with opportunistic infection and debilitation by parasites will likely increase. Further work on parasite loads in healthy and moribund Steller sea lions will assist in answering this question.

In Alaska, interactions between Steller sea lions and fisheries in the form of competition for food resources, by-catch mortalities, interruptionof feeding patterns, shooting to protect gear, and shooting of an indiscriminate nature have increased with greater fishing pressure (Alverson 1992). The gunshot wounds in the cranium of SSL 5, and the traumatic evidence for it in SSL4, suggests that interactions of Steller sea lions with fisheries in California needs further study.

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LITERATURE CITED

Alverson, D.L. 1992. A review of commercial fisheries and Steller sea lion (*Eumetopias jubatus*): The conflict arena. Reviews in Aquatic Sciences 6:204-256.

Bartholomew, G.A. and R.A. Boolootian. 1960. Numbers and population structure of the pinnipeds on the California Channel Islands. Journal of Mammalogy 4:366-375.

Bonnot, P. and W.E. Ripley. 1948. The California sea lion census for 1947. California Fish and Game 34:89-92.

Gerber, J.A., J. Roletto, L.E. Morgan, D.M. Smith, and L. Gage. 1993. Findings in stranded pinnipeds along the central and northern California coastline, 1984-1990. Journal of Wildlife Disease 29:423-433.

Howard, E.B, J.O. Britt Jr., G.K. Matsumoto, R. Itahara, and C.N. Nagano. 1983. Bacterial diseases. Pages 69-118 *in*: E.B. Howard, editor. Pathobiology of marine mammal diseases. Volume 1. CRC Press, Boca Raton, Florida, USA.

Loughlin, T.R. and R.L. Merrick. 1989. Comparison of commercial harvest of walleye pollock and northern sea lion abundance in the Bering Sea and Gulf of Alaska. Pages 679-699 *in:* Proceedings of the international symposium on the biology and management of walleye pollock. Alaska Sea Grant Report No. 89-1. University of Alaska, Anchorage, Alaska, USA.

Loughlin, T.R. and R. Nelson, Jr. 1986. Incidental mortality of northern sea lions in Shelikof Strait, Alaska. Marine Mammal Science 2:14-33.

Loughlin, T.R., M.A. Perez, and R.L. Merrick. 1987. *Eumetopias jubatus*. Mammalian species, No. 283. The American Society of Mammalogists, Provo, Utah, USA.

Loughlin, T.R., A.S. Perlov, and V.A. Vladimirov. 1992. Range wide survey and estimation of total number of Steller sea lions in 1989. Marine Mammal Science 8:222-239.

Mathisen, O.A., R.T. Baade, and R.J. Lopp. 1962. Breeding habits, growth and stomach contents of the Steller sea lion in Alaska. Journal of Mammalogy 43:469-477.

Misdorp, W. 1990. General considerations. Pages 1-22 *in:* J.E. Moulton, editor. Tumors in domestic animals, 3rd edition. University of California Press, Berkeley, California, USA.

Pascual, M.A. and M.D. Adkison. 1994. The decline of the Steller sea lion in the northeast Pacific: Demography, harvest or environment? Ecological Applications 4:393-403.

Perlov, A.S. 1971. The onset of sexual maturity in sea lions. Proceedings of the All Union Institute of Marine Fisheries and Oceans 80:174-187.

Pitcher, K.W. and D.G. Calkins. 1981. Reproductive biology of Steller sea lions in the Gulf of Alaska. Journal of Mammalogy 62:599-605.

Scheffer, V.B. 1958. Seals, sea lions and walruses. Stanford University Press, Stanford, California, USA.

Stewart, B.S., P.K. Yochem, R.L. DeLong, and G.A. Antonelis. 1993. Trends in abundance and status of pinnipeds on the southern California Channel Islands. Pages 501-516 *in*: F.G. Hochberg, editor. Third California islands symposium: Recent advances in research on the California islands. Santa Barbara Museum of Natural History, Santa Barbara, California, USA.

Stroud, R.K. and T.J. Roffe. 1979. Causes of death in marine mammals stranded along the Oregon coast. Journal of Wildlife Disease 15:91-97.

Sweeney, J.C. 1974. Common diseases of pinnipeds. Journal of the American Veterinary Medical Association 165:805-810.

Sweeney, J.C. and W.G. Gilmartin. 1974. Survey of diseases in free-living California sea lions. Journal of Wildlife Disease 10:370-374.

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ZOOPLANKTERS CONSUMED BY BLUE ROCKFISH DURING BRIEF ACCESS TO A CURRENT OFF CALIFORNIA'S SONOMA COAST

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The blue rockfish, *Sebastes mystinus*, feeds mainly on larger gelatinous zooplankters, including scyphozoans, ctenophores, and thaliaceans (Gotshall et al. 1965, Love and Ebeling 1978, Hallacher and Roberts 1985). These prey are most available when surface waters flow shoreward during intermittent relaxation of coastal upwelling (Hobson and Chess 1988). Although the trophic relations involved were broadly defined by Hobson and Chess (1988), recent events off Horseshoe Point, Sonoma County, California (39° 13' N, 123° 14' W) added insightful detail.

This new information came to us on 14 September 1994, when one of our regular sampling sessions was interrupted by a current rich in pelagic organisms. The setting was in about 10 m of water over large boulders at the outer edge of a bed of bull kelp, *Nereocystis leutkeana*. We had sampled blue rockfish and plankton here since 1987, and on this day arrived at 0900 h to find the sea calm, 10°C at the surface, and without evidence of a current. Also, there was no detectable wind, a condition that relaxes upwelling along this coast (Hobson and Chess 1988).

Equipped with SCUBA, and using methods developed earlier (Hobson and Chess 1976, 1988), we began collecting the standard set of samples. Between 1000 and 1010 h, one of us speared 10 adult blue rockfish (245-320 mm standard length [SL], $\bar{x}$ = 294) and, from 1013 to 1018 h, the other two pushed a 1-m net (333-μ mesh) through the water to sample the plankton (at varied depths between the surface and 2 m above the sea bed). The fish came from one large assemblage that occupied most of the upper half of the water column and the plankton came from close to this assemblage.

The plankton collection had been underway for approximately 2 min when the site was enveloped by a strong current that flowed southward along the coast. Immediately the water was warmer (11.3°C at 1030 h) and, whereas previously larger zooplankters had not been visible, now we could see numerous siphonophores (e.g.,*Stephanomia*), scyphozoans (e.g.,*Aurelia*), ctenophores (e.g.,*Beroe*, *Bolinopsis*, and *Pleurobrachia*), pteropods (e.g., *Corolla*), and other gelatinous forms. These pelagic organisms ordinarily occur offshore, but often are transported into nearshore habitats by onshore surface currents that develop in the absence of upwelling (Hobson and Chess 1988).

The current flowed through the site for approximately 15 min, then abruptly ceased and was followed by a 15-min period of slack water. At 1045 a second current arrived that was similar to the first, but lasted only 10 min and lacked visible zooplankters. No further currents, and only a few zooplankters, were noted during the 20 min we remained on station.

Recognizing that blue rockfish with access to the first current also had access to preferred prey, two of us reentered the water between 1055 and 1105 and took an additional 12 specimens (236-320 mm SL, $\bar{x}$ = 294) from the same assemblage as before. The stomach contents of fish from the two collections included similar amounts of plant material, but those of fish in the second collection also included far more and varied animal matter (Fig. 1), virtually all of it representing species that had been present in the current (Table 1).

Certain organisms carried in the current apparently were selected as prey, while others were rejected. The thaliacean *Thalia democratica* and the pelagic gastropods *Caranaria japonica* and *Corolla spectabilis* seemed especially preferred (Table 1), perhaps because their relatively large size, limited mobility, and lack of armor (or other defensive structures) made them vulnerable to blue rockfish. Obviously, it was also important that they were prominent in the plankton.

Other prominent zooplankters that shared some, but not all, of these features were only minor components of the diet. The polychaete *Tomopterus* sp., for example, was about the same size and more abundant in the current than *T. democratica*; however, *Tomopterus* sp. was scarce among the stomach contents (Table 1), possibly because its greater mobility made it an elusive prey. Similarly, chaetognaths of sizes

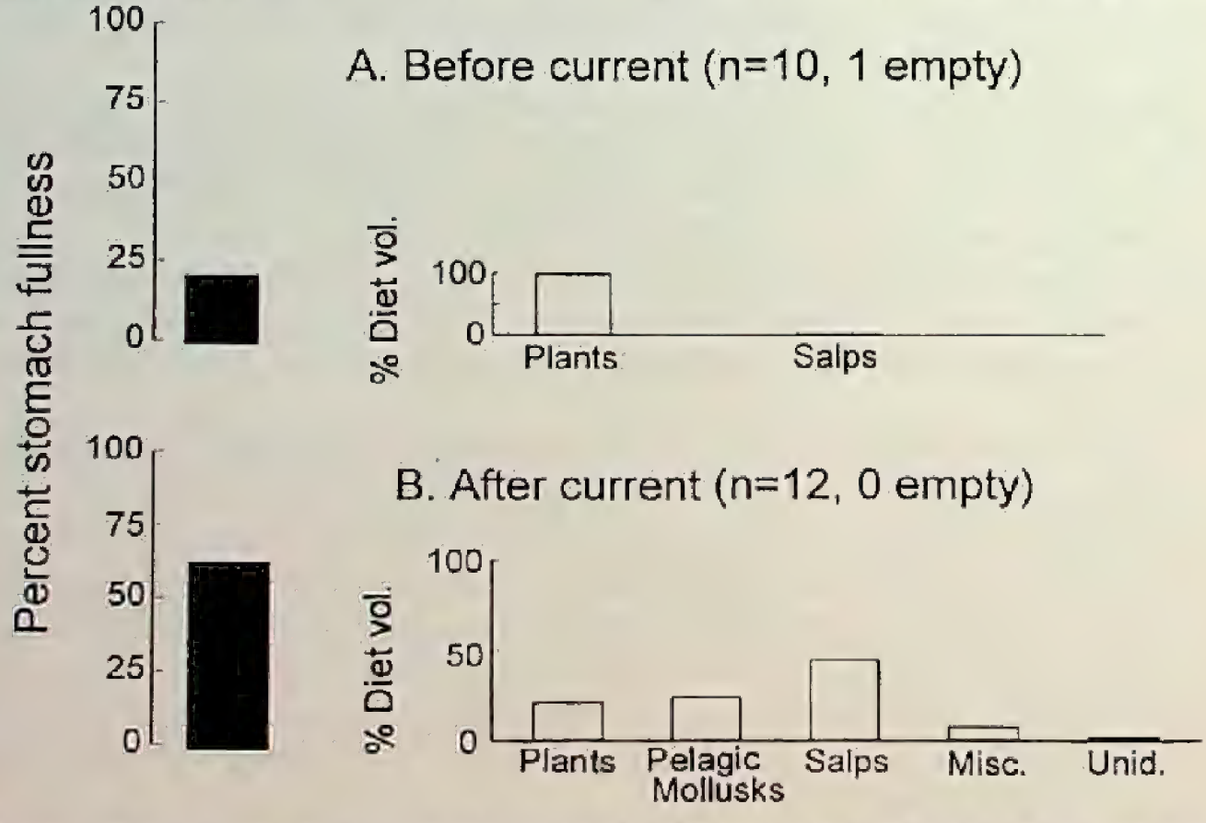

Figure 1. Diet of blue rockfish collected before and after exposure to a current on 14 September 1994 off Horseshoe Point, Sonoma County, California.. Percent fullness is based on visual estimates made during examination of the contents.

Table 1. Food of 12 adult blue rockfish (236-316 mm SL) sampled after inflow of zooplankters on 14 September 1994 off Horseshoe Point, Sonoma County, California.

		In Diet				In Plankton		
Rank	Food organism	Size (mm)	% occur.	$\bar{x}$ no.	$\bar{x}$ vol.	Size (mm)	$\bar{x}$ no.	$\bar{x}$ vol.
1	THALIACEA	**3-15**	**100**	**160.00**	**44.5**	**3-20**	**613**	**21.0**
	Thalia democratica	3-12	100	159.35	44.3	4-13	430	20.0
	Salpa fusiformis	15	8	0.67	0.2	0	0	0
	Other	—	0	0	0	3-20	183	1.0
2	PELAGIC GASTROPODA	**2-40**	**83**	**4.58**	**24.4**	**3-35**	**10**	**15.1**
	Heteropods							
	Carinaria japonica	16-40	33	0.75	6.5	—	0	0
	Pteropods							
	Corolla spectabilis	10-30	75	3.58	17.8	10-35	5	15.0
	Limacina helicina	2-3	25	0.25	<0.1	3	5	<0.1
3	PLANTS	**10-220**	**50**	**2.33**	**21.7**	NR	NR	NR
	Nereocystis sori	5-220	50	1.30	21.2	—	—	—
	Porphyra sp.	10-15	3	0.50	0.5	—	—	—
4	POLYCHAETA	**4-11**	**67**	**5.26**	**1.3**	**4-11**	**622**	**20.1**
	Tomopteris sp.	4-11	67	4.92	1.1	4-11	620	20.0
	Terebellid juveniles	7-8	17	0.17	<0.1	0	0	0
	Alciopid sp.	8	8	0.17	<0.1	7	2	<0.1
5	PELAGIC HYDROZOA	**5-12**	**67**	**2.33**	**0.5**	**3-24**	**101**	**11.1**
	Siphonophora							
	Muggiaea atlantica	10-12	33	0.75	0.3	4-9	65	4.0
	Stephanomia bijuga	5-12	50	1.50	0.2	3-7	18	1.0
	Calycophoran	7	8	0.08	<0.1	0	0	0
	Other	—	0	0	0	4-24	18	6.1
6	CTENOPHORA	**18-35**	**33**	**0.33**	**2.3**	**4-12**	**4**	**0.2**
	Beroe cucumis	18-35	33	0.33	2.3	12	1	<0.1
	Other	0	0	0	0	4-8	3	<0.1
7	HYPERIIDEA	**1-5**	**42**	**0.75**	**<0.1**	**2-16**	**14**	**0.3**
	Hyperoche sp.	1-5	33	0.58	<0.1	3-4	2	0.1
	Vibilia sp.	2-3	17	0.17	<0.1	—	0	0
	Other	—	0	0	0	2-16	14	0.4
8	MYSIDACEA	**3-10**	**25**	**0.42**	**<0.1**	**3-7**	**3**	**0.2**
	Proneomysis wailesi [a]	3-10	17	0.33	<0.1	3-7	12	0.1
	Holmesymysis costata	8	8	0.17	<0.1	6	2	<0.1

Table 1. Continued.

Rank	Food organism	In Diet: Size (mm)	In Diet: % occur.	In Diet: $\bar{x}$ no.	In Diet: $\bar{x}$ vol.	In Plankton: Size (mm)	In Plankton: $\bar{x}$ no.	In Plankton: $\bar{x}$ vol.
9	CALANOIDA	**3-5**	**33**	**0.34**	**<0.1**	**2-7**	**8300**	**27.0**
	Calanus pacificus	3	17	0.17	<0.1	2-4	7400	21.0
	Eucalanus californicus	5	17	0.17	<0.1	4-7	360	5.0
	Other	—	0	0	0	1-2	540	1.0
10	CYLOPOIDA	**2-3**	**25**	**0.33**	**<0.1**	**3**	**2**	**0.1**
	Sapphirina sp.	2-3	25	0.33	<0.1	3	2	<0.1
	Other	—	0	0	0	1	20	<0.1
OTHER CATEGORIES								
	Cirripedean larvae	—	0	0	0	<1-2	20	<0.1
	Euphausiacea	8	8	0.08	<0.1	4-6	11	<0.1
	Natantian larvae	—	0	0	0	2-6	15	<0.1
	Chaetognatha	8	8	0.08	<0.1	11-53	130	3.0
	Invertebrate eggs	<1-1	17	NR	0.6	—	0	0
	Fish larvae	15	8	0.17	<0.1	—	0	0

[a]Table excludes 210 *P. wailesi* that were packed together in the posterior part of the stomach of one blue rockfish, see text.

that should have been vulnerable to blue rockfish were highly abundant in the current, but only one small individual was found in the stomachs (Table 1). Probably chaetognaths were especially difficult to capture, being not only highly mobile, but also essentially transparent and, therefore, hard to see.

The siphonophores *Muggiaea atlantica* and *Stephanomia bijuga* were similar to *T. democratica* in size, form, and abundance and probably were just as easy to capture. But few occurred among the stomach contents, perhaps because they are armed with nematocysts. It is known that nematocysts deter predators, which would explain not only why so few hydrozoans were eaten by blue rockfish examined here, but also why so few of the most abundant hydrozoan in earlier plankton samples from Mendocino County, California (the hydromedusa *Eutonia indicans*) were eaten by blue rockfish there (Hobson and Chess 1988).

Although the blue rockfish has a smaller mouth than most of its congeners, presumably as an adaptation to planktivory (Hallacher and Roberts 1985), adults of the species nevertheless appear limited to prey larger than about 5 mm (Hobson and Chess 1988). An inability to ingest prey of smaller size may explain why fish examined here had consumed so few of the highly abundant calanoid copepods (Table 1). Calanoids and other planktonic crustaceans sampled close to where the fish were feeding tended to be <5 mm long, with most <3 mm (Table 1).

Despite the apparent limitation on taking small prey, the most frequently

occurring planktonic crustaceans in blue rockfish stomachs, the hyperiids *Hyperoche* sp. and *Vibilia* sp., were ≤5 mm (Table 1). These, however, are associates of ctenophores and thaliaceans (Brusca 1970, Laval 1980), and probably were ingested incidentally when the fish consumed their larger hosts (Hobson and Chess 1988).

The mysid *Proneomysis wailesi* was only a minor presence in the current, but most were >5 mm in length (Table 1). Two individuals mixed with other zooplankters in each of two fish from the second collection were the only ones we have reason to believe came from the plankton. There were 210 of them, 7-10 mm long, in a third fish from that collection, but these are excluded from the analysis because they were concentrated in the posterior part of the stomach and so presumably were ingested before the current arrived. At the time of these observations, there was an immense swarm of *P. wailesi* spread like a blanket within a few centimeters of the sea bed over much of the study site. Blue rockfish are known to feed on mysids and other epibenthic crustacea (>5 mm) when more preferred prey are unavailable (Hobson and Chess 1988), so one might wonder why there were none in fish collected before the current arrived.

Virtually all of the plant material ingested by blue rockfish were sori of bull kelp. These are reproductive structures that develop in fronds near the water's surface and drop out when mature. As the sori sink toward the bottom, many are consumed by blue rockfish, especially when more preferred foods are unavailable (Hobson and Chess 1988). We consider it likely that at least most of the plants found in fish from the second collection had been consumed before the current arrived.

These observations support our earlier hypothesis (Hobson and Chess 1988) that blue rockfish are adapted to exploit prey transported shoreward during intermittent relaxations of coastal upwelling. They also provide some explanation for the episodic nature of feeding in this species, as well as the patchiness that characterizes the distribution of its prey.

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LITERATURE CITED

Brusca, G.J. 1970. Notes on the association between *Hyperoche medusarum*, A. Agassiz (Amphipoda, Hyperiidea), and the ctenophore *Pleurobranchia bachei* (Muller). Bulletin of the Southern California Academy of Sciences 69:179-181.

Gotshall, D.W., J.G. Smith, and A. Holbert. 1965. Food of the blue rockfish, *Sebastes mystinus*. California Fish and Game 51:147-162.

Hallacher, L.E. and D.A. Roberts. 1985. Differential utilization of space and food by the inshore rockfishes (Scorpaenidae: *Sebastes*) of Carmel Bay. Environmental Biology of Fishes 12:91-110.

Hobson, E.S. and J.R. Chess. 1976. Trophic interactions among fishes and zooplankters near shore at Santa Catalina, California. Fishery Bulletin 74:567-598.

Hobson, E.S. and J.R. Chess. 1988. Trophic relations of the blue rockfish, *Sebastes mystinus*,

in a coastal upwelling system off northern California. Fishery Bulletin 86:715-746.
Laval, P. 1980. Hyperiid amphipods as crustacean parasitoids associated with gelatinous zooplankton. Pages 11-56 *in:* M. Barnes, editor. Oceanography and marine biology, annual review 18. Aberdeen University Press, Aberdeen, Scotland.
Love, M.S. and A.W. Ebeling. 1978. Food and habits of three switch feeding fishes in the kelp forests off Santa Barbara, California. Fishery Bulletin 76:257-271.

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FIRST RECORD OF THE GREEN CRAB, *CARCINUS MAENAS*, IN HUMBOLDT BAY, CALIFORNIA

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Native to Europe, the green crab, *Carcinus maenas*, was introduced to eastern North America in the early 19th Century and since has become established in only three other parts of the world: Australia (Fulton and Grant 1900); South Africa (Le Roux et al. 1990); and, most recently, California (Cohen et al. 1995, Grosholz and Ruiz 1995). In California, it was first noted in San Francisco Bay in 1990 (Cohen et al. 1995) and, soon thereafter, in Bodega Harbor, Bolinas Lagoon, Tomales Bay, and Drake's Estero (Grosholz and Ruiz 1995). Cohen et al. (1995) suggested that introduction to the eastern Pacific was either through shipping activity (via ballast water discharge or seawater pipe fouling), through commercial fisheries products, by accidental or intentional release through school or research aquaria, or by intentional release by private parties as a potential food resource.

I report here the arrival of the green crab in Humboldt Bay in northern California. The first specimens were caught by hand on 24 June 1995 on the east side of Arcata Bay (40°49' 51" N, 124°04' 57" W) (Table 1). They were found together just below the waterline on the edge of a mudflat tidal channel draining Bracut Slough. The substrate consisted of mud, silt, clay, and some cobble. Subsequent sampling of the site between June and September resulted in additional live specimens and exuviae (Table 1). Preserved material is deposited at the California Academy of Sciences (CAS 103348) and at the Humboldt State University Department of Biological Sciences.

All specimens displayed distinctive features of the green crab as described by Rice and Ingle (1975), including (i) five pairs of antero-lateral spines along the dorsal carapace (fifth antero-lateral spine pointing anteriorly), (ii) last pair of hind walking legs relatively flat, and (iii) patches of yellow coloration on the dorsal carapace. The ventral carapace has been described as variable in color with individuals having dark green, orange, and red coloration (McGaw et al. 1992). Specimens collected in Humboldt Bay displayed similar variability in ventral carapace coloration (Table 1). Among male crabs, the dark orange color of the ventral carapace apparently indicates that molting has not taken place recently; presumably such individuals are in extended intermolt (Kaiser et al. 1990, McGaw et al. 1992). Dark green color indicates a recently molted crab (Kaiser et al. 1990, McGaw et al. 1992).

Time of introduction and establishment of the green crab in Humboldt Bay are unknown. Introduction likely resulted from activities suggested by Cohen et al.

Table 1. Collection data for green crabs in Humboldt Bay, California. Specimens were live unless otherwise noted.

Collection date	Sex	Carapace width (mm)	Color: Ventral carapace	Color: Arthroidal membrane	Water temp. (°C)	Salinity (ppt)
24 June 1995	M	79.4	orange	red	18	15
	M	82.6	white	clear		
29 June 1995	F	74.1	green	clear	22	18.5
21 July 1995	F	63.4	red	red	18.5	30
	F	66.8	red	red		
	M	88.4	red	red		
24 Sept. 1995	F	45.9 (exuvia)				
	–	44.7 (exuvia)				

(1995) or by natural dispersal from an established population to the south, specifically the Bodega Harbor-Tomales Bay area (Grosholz and Ruiz 1995). Grosholz and Ruiz (1995) predicted that seasonal northerly currents, such as the Davidson Current (Hickey 1989), would spread larvae north from established green crab populations in Bodega Harbor and embayments farther south. Green crabs in Bodega Harbor are reproductively active (Grosholz and Ruiz 1995) and may have provided larvae for establishment in Humboldt Bay.

The green crab can be a potential threat to native fauna and commercially important species (Welch 1969, Le Roux et al. 1990). Cohen et al. (1995) speculate in detail on the potential ecological and economic impacts of the green crab in San Francisco Bay, and Grosholz and Ruiz (1995) provide data on observed impacts on the infauna in Bodega Harbor. Bivalves and gastropods are a primary food source of the green crab (Ropes 1969, Elner 1981, Jensen and Jensen 1985, Rangeley and Thomas 1987, Cohen et al. 1995, Grosholz and Ruiz 1995), and it feeds readily on spat of the Pacific oyster, *Crassostria gigas* (Richardson et al. 1993); the Japanese cockle, *Venerupis philippinarum* (Cohen et al. 1995); the bay mussel, *Mytilus* spp. (Elner 1981, Jensen and Jensen 1985); and the soft shell clam, *Mya arenaria* (Cohen et al. 1995), all of which occur in California estuaries. Native species of crabs within the bay, specifically the Dungeness crab, *Cancer magister*, could also be greatly impacted. Laboratory observations by Grosholz and Ruiz (1995:245) found that green crabs prey on Dungeness crabs and shore crabs, *Hemigrapsus* spp., "of equal or smaller size". In view of its predatory behavior and the predictions by Grosholz and Ruiz (1995), the green crab may pose a substantial threat to benthic communities and commercial oyster culture in Humboldt Bay, presently the largest supplier of

Pacific oysters in California (Conte 1992). A detailed study of the distribution, abundance, and impacts of the green crab in Humboldt Bay is warranted.

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LITERATURE CITED

Cohen, A.N., J.T. Carlton, and M.C. Fountain. 1995. Introduction, dispersal and potential impacts of the green crab *Carcinus maenas* in San Francisco Bay. California Marine Biology 122:225-237.

Conte, F.S. 1992. Oysters. Pages 183-187 *in:* W.S. Leet, C.M. Dewees, and C.W. Haugen, editors. California's living marine resources and their utilization. California Sea Grant, Sea Grant Extension Publication UCSGEP-92-12.

Elner, R.W. 1981. Diet of the green crab *Carcinus maenas* (L.) from Port Hebert, southwestern Nova Scotia. Journal of Shellfish Research 1:89-94.

Fulton, S.W. and F.E. Grant. 1900. Note on the occurrence of the European crab, *Carcinus maenas*, Leach, in Port Phillip. Victorian Naturalist 27:147-148.

Hickey, B.M. 1989. Patterns and processes of circulation over the Washington continental shelf and slope. Pages 41-115 *in:* M.R. Landry and B.M. Hickey, editors. Coastal oceanography of Washington and Oregon. Elsevier Science Publishing Company, New York, New York, U.S.A.

Grosholz, E.D. and G.M. Ruiz. 1995. Spread and potential impact of the recently introduced European green crab *Carcinus maenas* in central California. Marine Biology 122:239-247.

Jensen, K.T. and J.N. Jensen. 1985. The importance of some epibenthic predators on the density of juvenile benthic macrofauna in the Danish Wadden Sea. Journal of Experimental Marine Biology and Ecology 89:157-174.

Kaiser, M.J., R.N. Hughes, and D.G. Reid. 1990. Chelal morphometry, prey size selection and aggressive competition in green and red forms of *Carcinus maenas* (L.). Journal of Experimental Marine Biology and Ecology 140:121-134.

Le Roux, P.J., G.M. Branch, and M.A.P. Joska. 1990. On the distribution and possible impact of the invasive European shore crab *Carcinus maenas* (L.) along the South African coast. South African Journal of Marine Science 9:85-93.

McGaw, I.J., M.J. Kaiser, E. Naylor, and R.N. Huges. 1992. Intraspecific variation related to the moult-cycle in colour forms of the shore crab *Carcinus maenas*. Journal of Zoology 228:351-359.

Rangeley, R.W. and M.L.H. Thomas. 1987. Predatory behavior of juvenile shore crab *Carcinus maenas* (L.). Journal of Experimental Marine Biology and Ecology 108:191-197.

Rice, A.L. and R.W. Ingle. 1975. The larval development of *Carcinus maeans* (L.) and *C. mediterraneus* (Crustacea, Brachyura, Portunidea) reared in the laboratory. Bulletin of the British Museum of Natural History (D: Zoology) 28:103-119.

Richardson, C.A., R. Seed, E.M.H. Al-Roumaihi, and L. McDonald. 1993. Distribution, shell growth and predation of the New Zealand oyster, *Tiostrea* (=*Ostrea*) *lutaria* Hutton, in the Menai Strait, North Wales. Journal of Shellfish Research 12:207-214.

Ropes, J.W. 1969. The feeding habits of the green crab, *Carcinus maenas* (L.). Fishery Bulletin 67:183-203.

Welch, W.R. 1969. Changes in abundance of the green crab, *Carcinas maenas* (L.), in relation to recent temperature changes. Fishery Bulletin 67:337-345.

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A BOAT-MOUNTED SYSTEM TO SYNOPTICALLY RECORD VESSEL POSITION AND SEA-SURFACE TEMPERATURE

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To facilitate the collection of spatial data, we developed an automated logging system to minimize data entry errors associated with sampling and to allow increases in (i) the areal and temporal resolution of sampling for vessel position and sea-surface temperature (SST) and (ii) the rate at which sampling transects are run. The system used a minimum of new or dedicated equipment and was inexpensive to assemble.

The automated logging system was first used during a study to determine the importance of oceanographic fronts in recruitment of near-shore rockfishes. A 7.6-m outboard-powered boat was fitted with the system to facilitate running geo-referenced SST sampling transects throughout the study area. Fronts were identified using satellite imaging and nearreal-time monitoring of SST isotherms. Young-of-the-year rockfish associated with oceanographic fronts were sampled with midwater trawls.

The system was set up with minimal additional equipment. A Loran-C and temperature sensor (LC-90 and T-2000, respectively, distributed by Furuno USA, Inc., South San Francisco, California[1]), each with electronic data output capability, were already installed on the boat and were used as data acquisition and output devices for vessel position and SST. We logged data to a portable personal computer configured with two serial communication ports. The only additional electronic devices inserted in the system were "black boxes" that ensured that each output device would interface correctly with the personal computer.

The black boxes (Navcon, manufactured by Maricom Electronics, Inc., Thunderbolt, Georgia[1]) convert the Loran-C and temperature sensor electronic data output from National Marine Electronics Association (NMEA) 0183 format to RS-

[1] Reference to trade names does not imply an endorsement by the California Department of Fish and Game.

232 format. The NMEA 0183 format is one of several standards used in marine electronics. The NMEA format uses particular electronic properties and sentence structure; sentence prefixes are coded to identify the type of electronic equipment generating the data (e.g., Loran-C, temperature sensor, or fathometer). The RS-232 format is a standard among manufacturers of personal computers.

We used readily-available cables to connect system components. Data cables from the Loran-C and temperature sensor to the black boxes were accessories available from marine electronics retailers. Standard nine-pin serial cables connected the black boxes to communication ports on the personal computer. We used two of 10 wires in the data cable from the Loran-C, two of four wires in the data cable from the temperature sensor (NMEA out and ground, in both cases), and two (receive and ground) of nine wires in each of the serial cables (Fig. 1).

The system is controlled by a small (approximately 40 kilobytes) DOS-based executable program written in Microsoft QuickBASIC (Table 1). The program toggles (open or closed) each serial communication port (Com1 and Com2) in response to the data stream sent from each black box. It assigns a separate string memory variable to input from each Com port (i.e., temperature from Com1 and position from Com2). Raw data are output to the screen to verify that the system is working. Each string is reformatted to remove extraneous characters (e.g., NMEA 0183 prefix characters). Finally, the program appends the two reformatted strings, along with a date and a time stamp, to an ASCII file.

We added customized features to the program as needed. The most recent version of the program prompts the user for, and controls, the sampling rate and duration of a session. It also outputs a second data file, formatted for use in a geographical information system.

This automated logging system has been in use along the central California coast

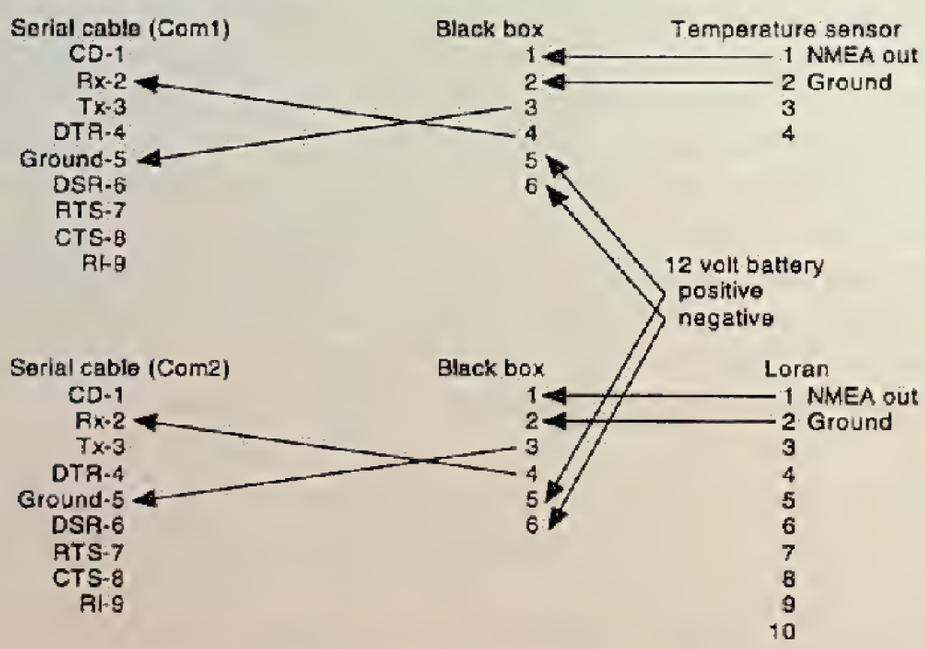

Figure 1. Schematic diagram for the wiring of system hardware.

Table 1. Simplified text of the program to synoptically record vessel position and sea-surface temperature, controlling only flow and format.

```
10    CLS
15    INPUT "PLEASE ENTER NAME OF OUTPUT TEXT FILE: ", T.DAT$
20          OPEN "COM 1 4800,N,8,1,RS,CS,DS" FOR INPUT AS #1
25          LINE INPUT #1, A$
30                ALEN% = LEN(A$)
35                IF ALEN% = 13 THEN
40                      PRINT A$
45                ELSE
50          CLOSE
55                      GOTO 20
60                END IF
65          CLOSE
70          OPEN "COM 2: 4800,N,8,1,RS,CS,DS" FOR INPUT AS #2
75          LINE INPUT #2, B$
80                BLEN% = LEN(B$)
85                IF BLEN% = 27 THEN
90                      PRINT B$
95                ELSE
100         CLOSE
105                     GOTO 70
110               END IF
115         CLOSE
120                     PRINT "TIME:", TIME$
125                     PRINT: PRINT
130         OPEN T.DAT$ FOR APPEND AS #3
135               A1$ = MID$(A$,8,4)
140               B1$ = MID$(B$,8,7)
145               B2$ = MID$(B$,18,8)
150         PRINT #3, DATE$, TIME$, A1$, B1$, B2$
155         CLOSE T.DAT
160         IF NOT EOF(1) THEN GOTO 20
```

for hundreds of hours and has been very reliable. Data files usually contain >1000 records, with <0.1% incomplete or garbled. The largest data file (2,700 records) to date was 324 kilobytes, a small fraction of available memory on the personal computer. The ASCII data files require little editing, and the system acquires a maximum of 30 samples/min.

We typically run transects at >37 km/h (one sample/20 m at maximum sampling resolution) for large-scale surveys. Precision is somewhat reduced at these relatively high speeds, due in part to the interaction of the time constant and reporting interval of the temperature sensor and Loran-C. For smaller scale surveys, we operate more slowly.

Creatively using appropriate commercial-quality instrumentation, with adequate

computing power, may be a reasonable alternative to often prohibitively expensive scientific instrumentation. We have used modifications of the original automated logging system in two other studies. The senior author used multiplexing output devices and inexpensive "palm-top" computers (with one megabyte of memory and a single communication port) to log similar data sets from scanning sonic-tag receivers. Using these components results in a significant cost savings compared to the use of a portable personal computer, though with some loss in versatility. We also wrote a QuickBASIC program that accepts input from a Loran-C and a commercial grade fathometer. With data collected using this system, instead of side-scanning SONAR or other sophisticated system, we have developed depth contour charts of study areas with finer areal resolution than available from most sources.

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OCCURRENCE OF PORCUPINES ALONG THE SAN JOAQUIN RIVER, FRESNO AND MADERA COUNTIES, CALIFORNIA

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Porcupines, *Erethizon dorsatum*, in central California are normally recorded as inhabiting the Sierra Nevada from the digger pine-oak belt to the lodgepole pine forests (Verner and Boss[1] 1980). This species is not recorded from the Central Valley of California (Grinnell 1933, Hall 1981), but Ingles (1965) noted that it could be found between Highway 50 and the City of Folsom near Lake Natomas and in Sacramento and Yolo counties. W. Grenfell (California Department of Fish and Game [CDFG], pers. comm.) has observed porcupines along the American River Parkway in Sacramento County and many years ago found a vehicle-killed porcupine on Highway 99 near Gridley in Butte County (39° 22' 29" N, 121° 39' 05" W).

On 10 September 1983, we recovered a vehicle-killed, 2.4-kg female porcupine 4.8 km north of the San Joaquin River, along Madera County Road 38 (36° 53' 16" N, 119° 51' 26" W). Based on tooth eruption (Dodge 1982), we concluded it was a juvenile. This area is in the midst of an intensively cultivated area at an elevation of 102 m. Land use in the area consists of 51% orchards, 27% pasture and grassland, 11% grape cultivation, and 5% wheat farming. A narrow band of riparian habitat along the San Joaquin River is dominated by cottonwood, *Populus* sp.; willow, *Salix* sp.; and a few large blue oaks, *Quercus douglasii*.

In addition to our specimen, and a vehicle-killed porcupine found on the entrance road to the San Joaquin Experimental Range (37° 05' 55" N, 119° 44' 53" W) 32 km north of Fresno in June 1953 (Newman and Duncan[2] 1973), we documented four other recent records of porcupines in Madera and Fresno counties. California Department of Fish and Game personnel captured porcupines from two areas just south of the San Joaquin River in Fresno County (R. Brueggemann, CDFG, pers. comm.): one at the corner of Shaw and Marks avenues (36° 48' 30" N, 119° 50' 40" W), 4.8 km south of the San Joaquin River in August 1982 and the other in June 1983 near

[1] Verner, J. and A.S. Boss, Technical Coordinators. 1980. California wildlife and their habitats: Western Sierra Nevada. USDA Forest Service General Technical Report PSW-37, Pacific Southwest Forest and Range Experiment Station, Berkeley, California, USA.

[2] Newman, T.F. and D.A. Duncan. 1973. Vertebrate fauna of the San Joaquin Experimental Range, California: A checklist. USDA Forest Service General Technical Report PSW-6, Pacific Southwest Forest and Range Experiment Station, Berkeley, California, USA.

the junction of Cornelia and Sierra avenues (36°49' 48" N, 119°52' 50" W), 2.5 km from the San Joaquin River. Both areas are urban, but contain small orchards and considerable ornamental tree cover. On 27 September 1959, A. Hawbecker (pers. comm.) found a vehicle-killed porcupine on the bridge crossing the San Joaquin River on Highway 41 (36°52' 34" N, 119°47' 31" W). During the summer of 1979, a farm dog fought a porcupine in the riparian zone of the San Joaquin River 28 km west of the location of the above records at the junction of Avenues 5-1/2 and 25-1/2, Madera County (36°49' 46" N, 120°05' 16" W) (W. Trayler, pers. comm.). Many quills had to be removed from the dog's mouth after this encounter.

Attempts to find other records of porcupine occurrence in Fresno and Madera counties were unsuccessful. We contacted 51 local veterinarians, but none reported any porcupine-caused injures to dogs from this area. None of the eight museums we contacted contained any specimens of porcupines from this area (University of California, Davis; Museum of Vertebrate Zoology, University of California, Berkeley; University of California, Los Angeles; San Diego Natural History Museum; California Academy of Sciences, San Francisco; California State University, Stanislaus; and California State University, Fresno).

Based on recorded occurrences, we conclude that a breeding population of porcupines may exist in the riparian and agricultural areas surrounding the San Joaquin River in Fresno and Madera counties.

LITERATURE CITED

Dodge, W.E. 1982. Porcupine *Erethizon dorsatum*. Pages 355-366 *in*: J.A. Chapman and G.A. Feldhamer, editors. Wild mammals of North America. The John Hopkins University Press, Baltimore, Maryland, USA.

Grinnell, J. 1933. Review of the recent mammal fauna of California. University of California Publications in Zoology 40:71-234.

Hall, E.R. 1981. The mammals of North America, 2nd edition. John Wiley and Sons, New York, New York, USA.

Ingles, L.G. 1965. Mammals of the Pacific states. Stanford University Press, Stanford, California, USA.

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FIRST CONFIRMED RECORD OF TELEOST PREDATION ON A SHARK EGG CASE

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A recent review by Cox and Koob (1993) showed that records of predation on elasmobranch egg cases are relatively rare. Some species of carnivorous gastropods may drill into and feed on embryos or developing young in egg cases of some oviparous sharks (McLaughlin and O'Gower 1971, Grover 1972, Cox and Koob 1993) and shark egg cases have been taken from stomachs of marine mammals and at least one species of shark (Morejohn and Baltz 1970, Varoujean[1] 1972, Jones 1981, Condit and Le Boeuf 1984, Antonelis et al. 1987, Sinclair 1994). Teleosts are the most likely and abundant predator on shark egg cases, but few cases of such predation have been documented. In this report I discuss what may be the first confirmed record of teleost predation on a shark egg case.

On 2 January 1994, I received a whole male kelp greenling, *Hexagrammos decagrammus*, (24.4 cm standard length) from an employee of the Stagnaro Fishing Company of Santa Cruz, California. The greenling was caught by hook and line in Soquel Canyon, Monterey Bay at a depth of 90-95 m. Examination of the greenling's stomach contents revealed four *Octopus* sp. beaks, remains of several crabs, and a whole shark egg case. The egg case was 67.2 mm total length and 24.4 mm wide. It was determined to be from the brown catshark, *Apristurus brunneus*, based on comparisons with illustrations and morphological descriptions provided in DeLacy and Chapman (1935), Cox (1963), and Eschmeyer et al. (1983). The egg case, apparently swallowed whole, was complete and showed no punctures or damage, although one of the tendrils was severed near the base. The egg case was curated into the Ichthyology Collection of the California Academy of Sciences (CAS 83558).

This may be the first accurately documented instance of teleost predation on a shark egg case and, although earlier records suggest such predation, apparently no observations of natural predation are to be found in the literature. Nichols (1931) produced a second-hand report of what may have been chain catshark, *Scyliorhinus retifer*, eggs taken from the stomach of an unidentified species of "sea bass" from an undetermined locality off the east coast of the United States and Grover (1972) reported observations of sheephead wrasse, *Semicossyphus pulcher*, biting egg cases of hornsharks, *Heterodontus francisci*, in a large aquarium. Although at least one

[1] Varoujean, D.H. 1972. Systematics of the genus *Echinorhinus* Blainville, based on a study of the prickly shark *Echinorhinus cookei* Pietschmann. M.S. Thesis, Fresno State College, Fresno, California, USA.

teleost is now known to feed on the eggs of the brown catshark, several other marine vertebrates also feed on their egg cases, namely the northern elephant seal, *Mirounga angustirostris*, (Morejohn and Baltz 1970, Jones 1981, Condit and Le Boeuf 1984); the Steller sea lion, *Eumetopias jubatus* (Jones 1981); and the prickly shark, *Echinorhinus cookei* (Varoujean[1] 1972). Considering that catshark egg cases are sessile and a potentially rich food source, it seems odd that records of teleost predation are so uncommon. This demonstrates the need for documentation of future observations.

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LITERATURE CITED

Antonelis, G.A., M.S. Lowry, D.P. DeMaster, and C.H. Fiscus. 1987. Assessing northern elephant seal feeding by stomach lavage. Marine Mammal Science 3:308-322.

Condit, R. and B.J. Le Boeuf. 1984. Feeding habits and feeding grounds of the northern elephant seal. Journal of Mammalogy 65:281-290.

Cox, D.L. and T.J. Koob. 1993. Predation on elasmobranch eggs. Environmental Biology of Fishes 38:117-125.

Cox, K.W. 1963. Egg-cases of some elasmobranchs and a cyclostome from Californian waters. California Fish and Game 49:271-289.

DeLacy, A.C. and W.M. Chapman. 1935. Notes on some elasmobranchs of Puget Sound, with descriptions of their egg cases. Copeia 1935:63-67.

Eschmeyer, W.N., E.S. Herald, and H. Hammann. 1983. A field guide to Pacific Coast fishes of North America. Peterson Field Guide Series #28. Houghton Mifflin Company, Boston, Massachusetts, USA.

Grover, C.A. 1972. Predation on egg-cases of the swell shark, *Cephaloscyllium ventriosum*. Copeia 1972:871-872.

Jones, R.E. 1981. Food habits of smaller marine mammals from northern California. Proceedings of the California Academy of Sciences 42:409-433.

McLaughlin, R.H. and A.K. O'Gower. 1971. Life history and underwater studies of a heterodont shark. Ecological Monographs 41:271-289.

Morejohn, G.V. and D.M. Baltz. 1970. Contents of the stomach of an elephant seal. Journal of Mammalogy 51:173-174.

Nichols, J.T. 1931. Egg capsule of *Scyliorhinus retifer*. Copeia 1931:38-39.

Sinclair, E.H. 1994. Prey of juvenile northern elephant seals (*Mirounga angustirostris*) in the Southern California Bight. Marine Mammal Science 10:230-239.

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